JAMES M. PLEASANTS COMPANY INC.

May 15, 2007

Pressure Independent Modulating Control Valves:
<u>Impact of Design or Greater Δ T</u>
on Chilled Water & Hot Water Systems

Presented by:
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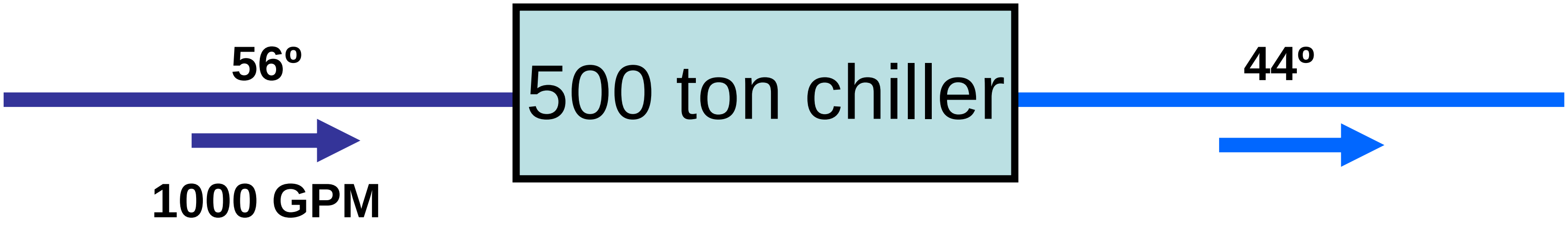
$$BTUH = 500 \times GPM \times \Delta t$$

$$Tons = \frac{500 \times GPM \times \Delta t}{12{,}000}$$

$$\frac{500 \times 1000 \times 12}{12{,}000} = 500 Tons$$

Design Conditions:



$$\frac{500 \times 1000 \times 12}{12{,}000} = 500\,Tons$$

Chiller is fully loaded

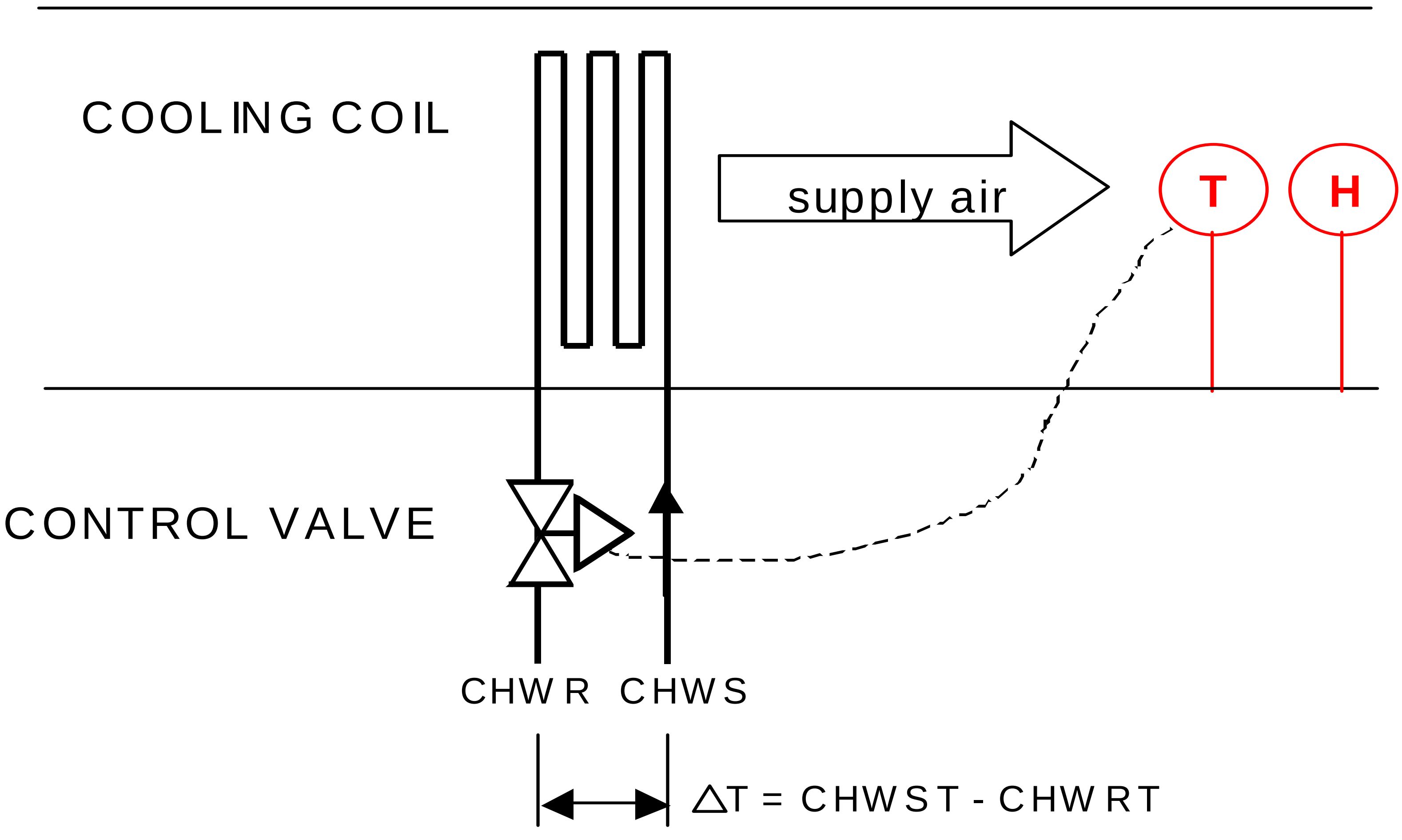
Low Δ T :

$$\frac{500 \times 1000 \times 10}{12{,}000} = 417\,Tons$$

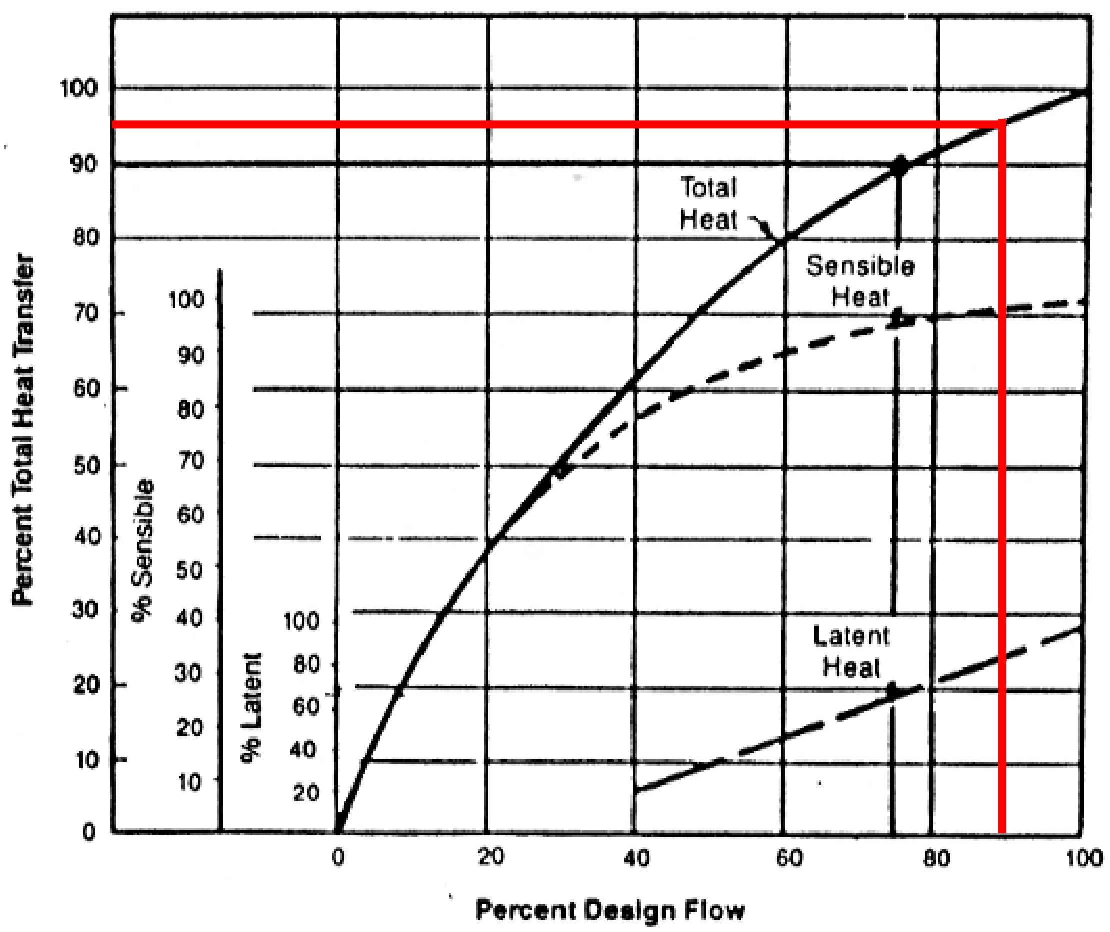
Chiller is 83% loaded

A.H.U. / Coil Performance:

What sets demand for chilled water?

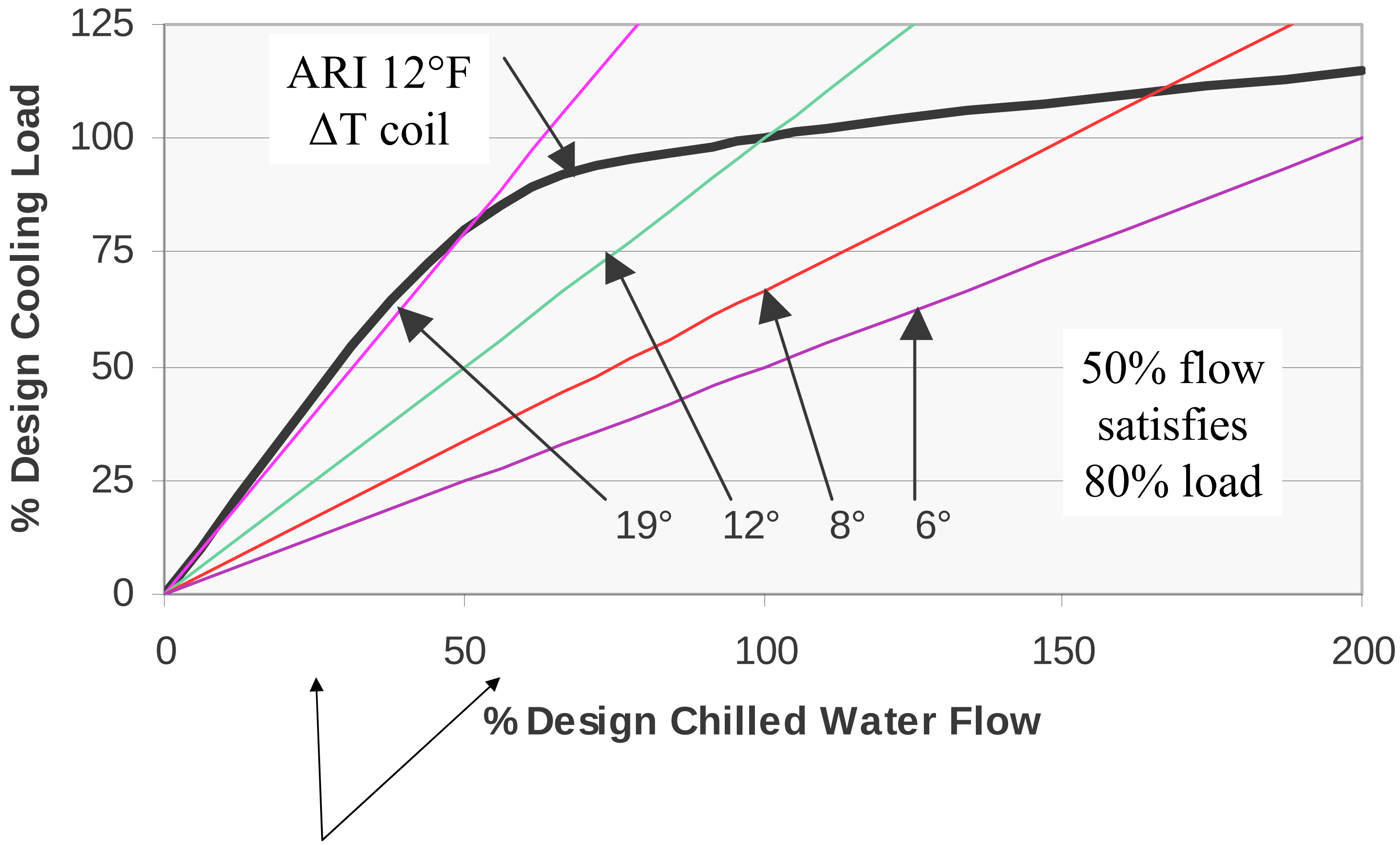


Cooling Coil Heat Transfer vs. Water Flow:



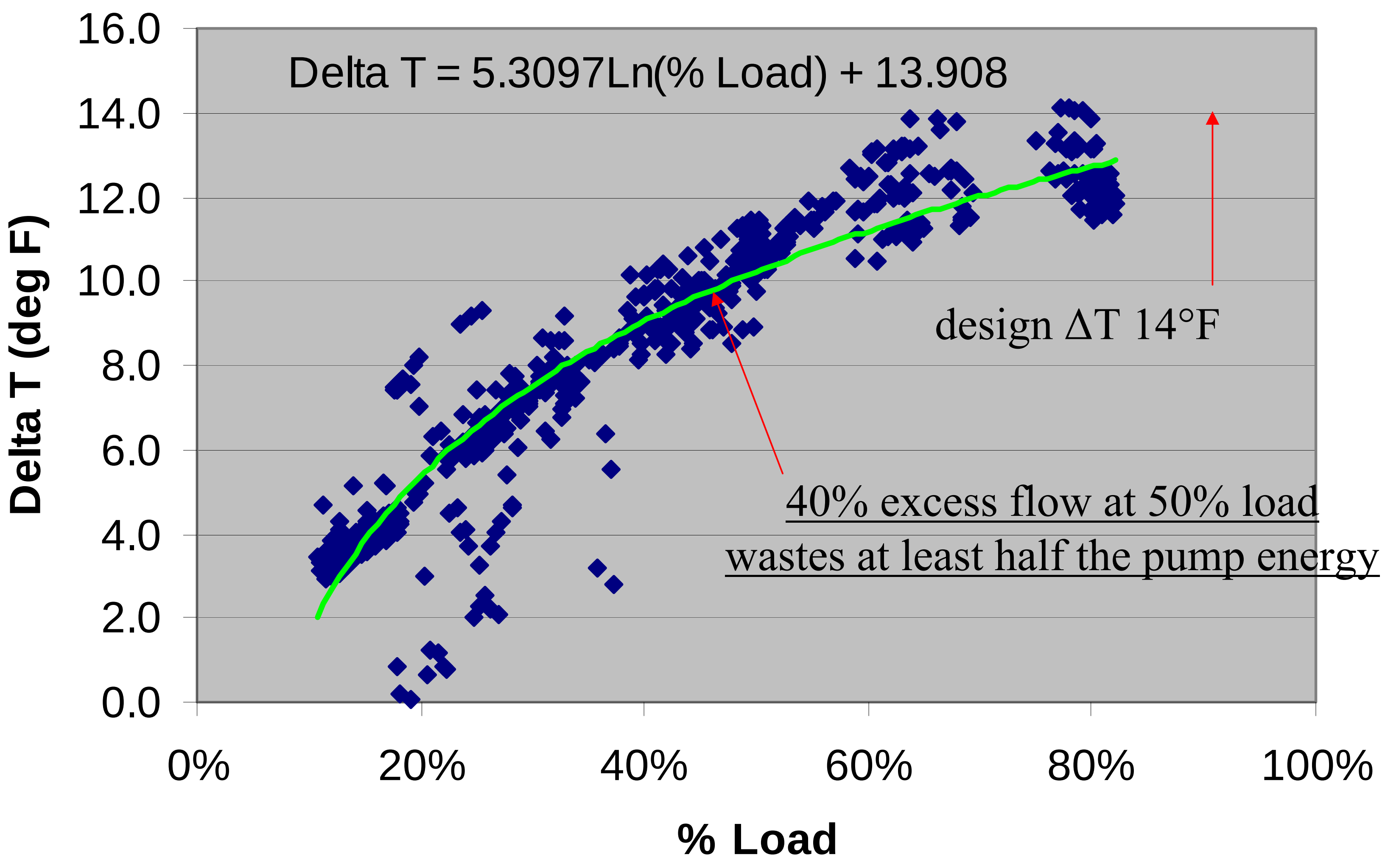
2003 ASHRAE Applications Handbook, p 37.8

How should a cooling coil perform?

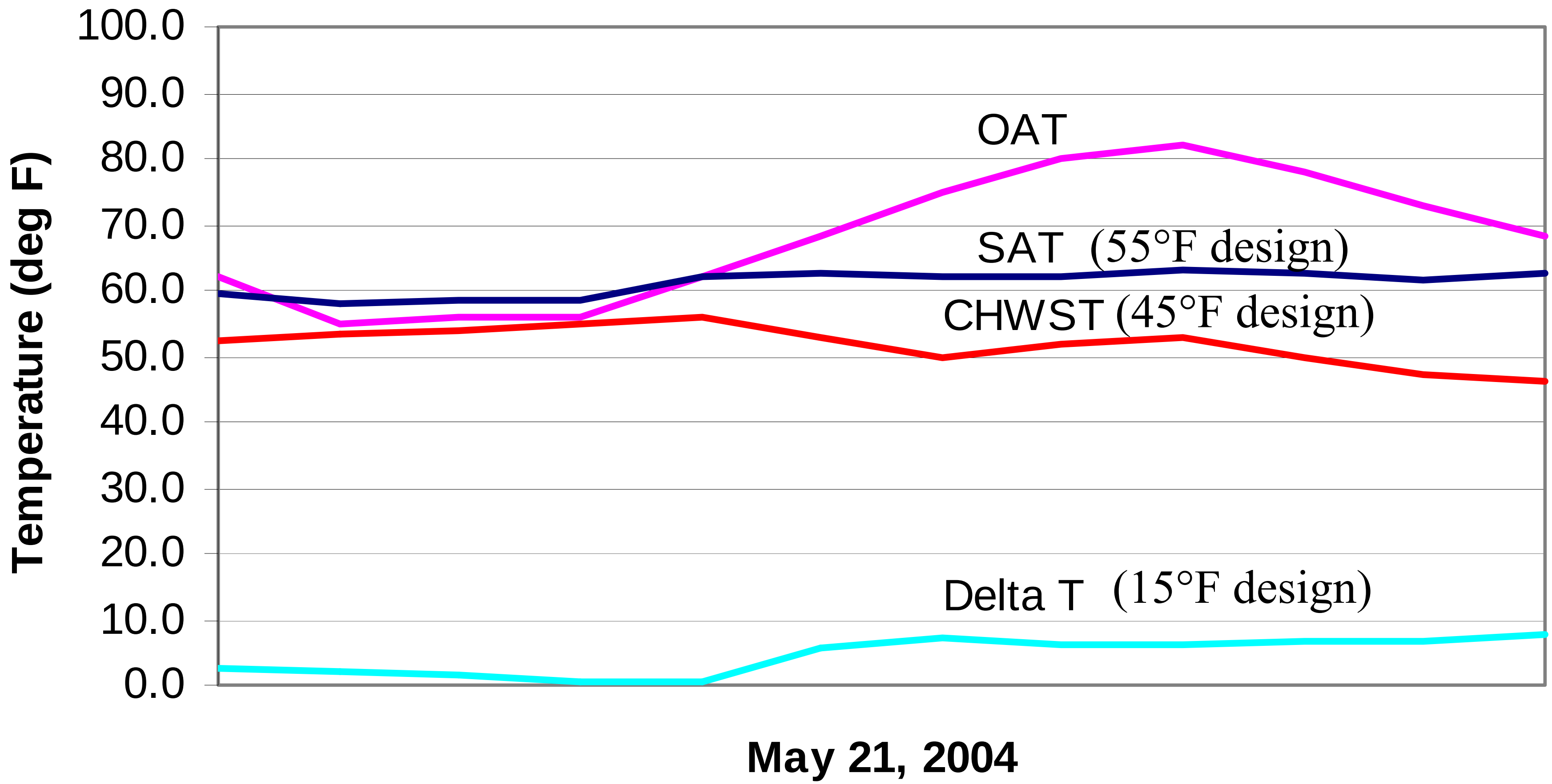


Control valves must modulate well in this range for good system performance!

Typical system with low ΔT:



Trend of poor performance



Why should ΔT exceed design?

- ΔT is a parameter used <u>in design at peak load</u> to size chillers, pipes, pumps, and cooling coils.
- <u>In operation at all loads</u>, ΔT is the most important measure of total distribution system performance.

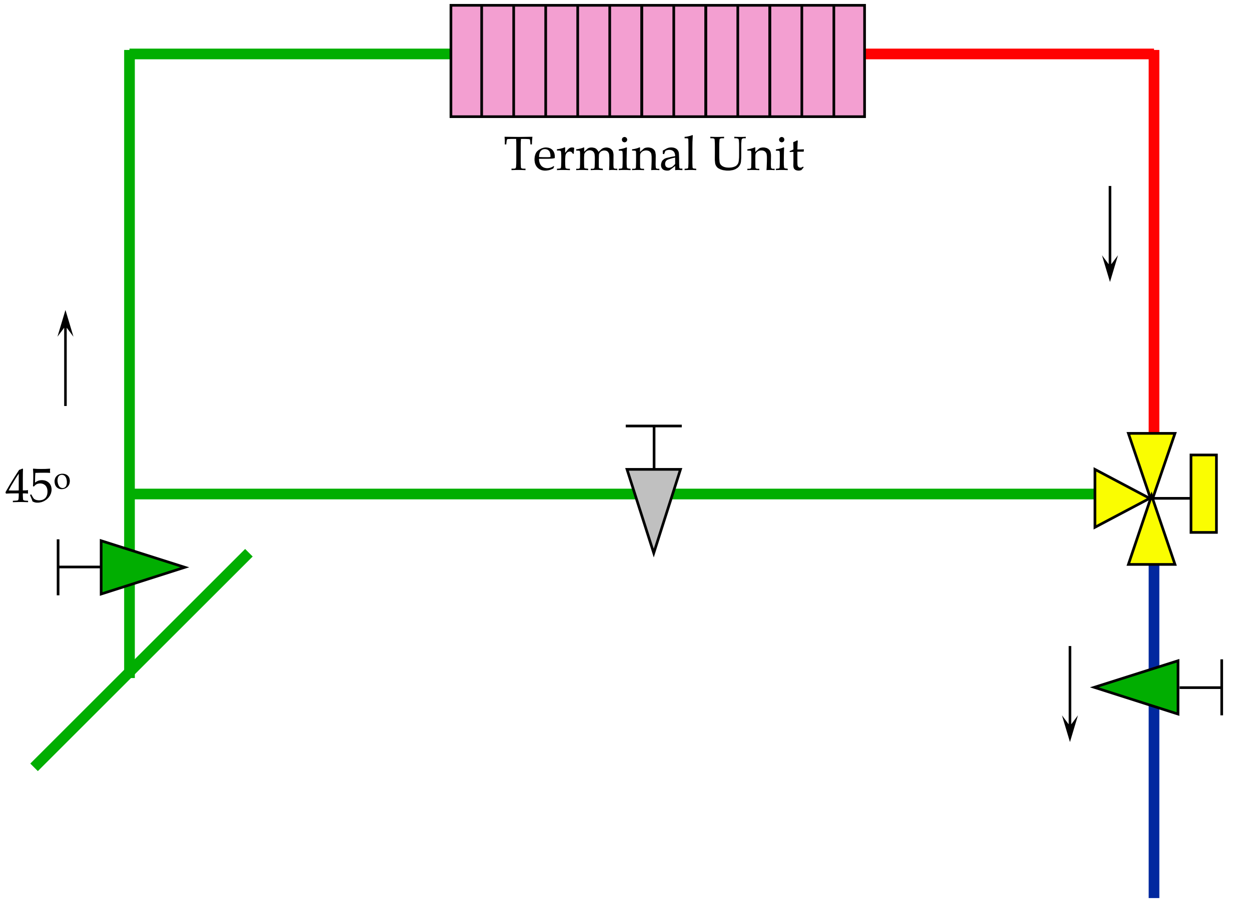
$$\frac{ton}{gpm} = \frac{\Delta T}{24}$$

Maximize available capacity
Increase tons/gpm
(chillers, pumps, pipes, coils)

$$\frac{gpm}{ton} = \frac{24}{\Delta T}$$

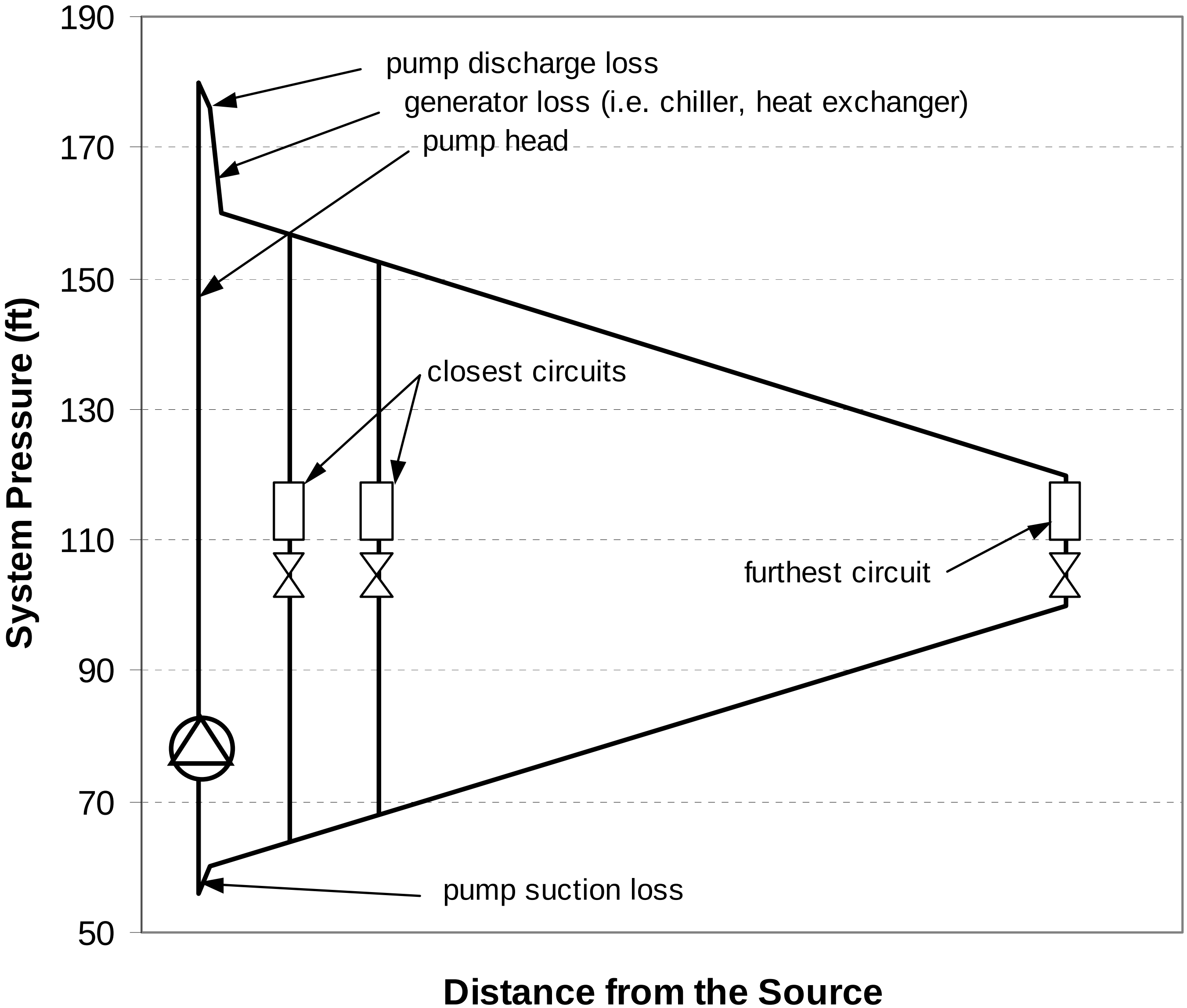
Minimize energy use
Decrease gpm/ton
(chiller plant, distribution, fans)

What Will Cause ΔT To Be Less Than Design AT THE COOLING COIL?



Three-Way Valve

What do pumps and control valves do?



Pumps generate system pressure.

Control valves must consume pressure to modulate flow.

WHAT CAN CAUSE LOW ΔT?

- Dirty or broken coils
- Not enough heat transfer surface
- Laminar flow (not really)

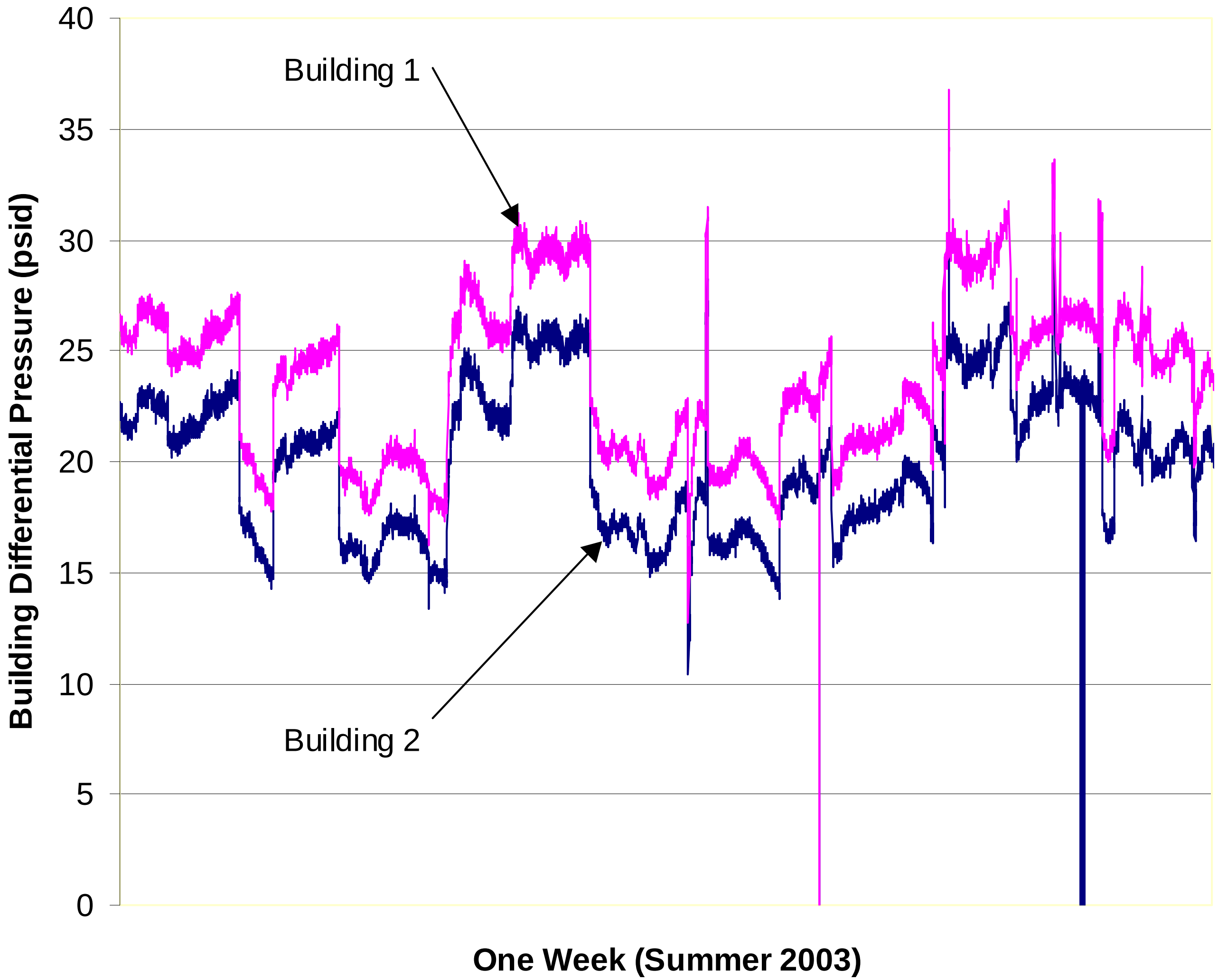
- Real time pressure fluctuations
- Rule of thumb control valve sizing
- Control valve rangeability and system turndown
- Rising supply water temperature to coils

real time system pressure fluctuations

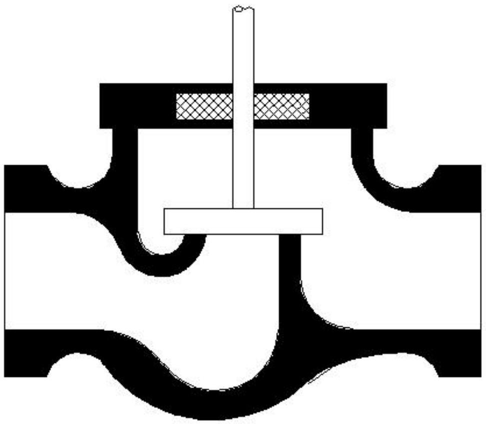
Cooling loads rise and fall

Control valves open and close to meet demand

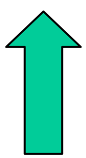
Pumps start, stop and change speed



Conventional control valves must react to both load and differential pressure changes.



Conventional Control Valve



Flow varies as differential pressure varies.

It takes TIME for a conventional control valve & actuator to react to differential pressure changes, with or without a load change.

Conventional control valve sizing issues:

- Rule of thumb valve sizing
- Hydraulic profile (today)
- Hydraulic profile (tomorrow)

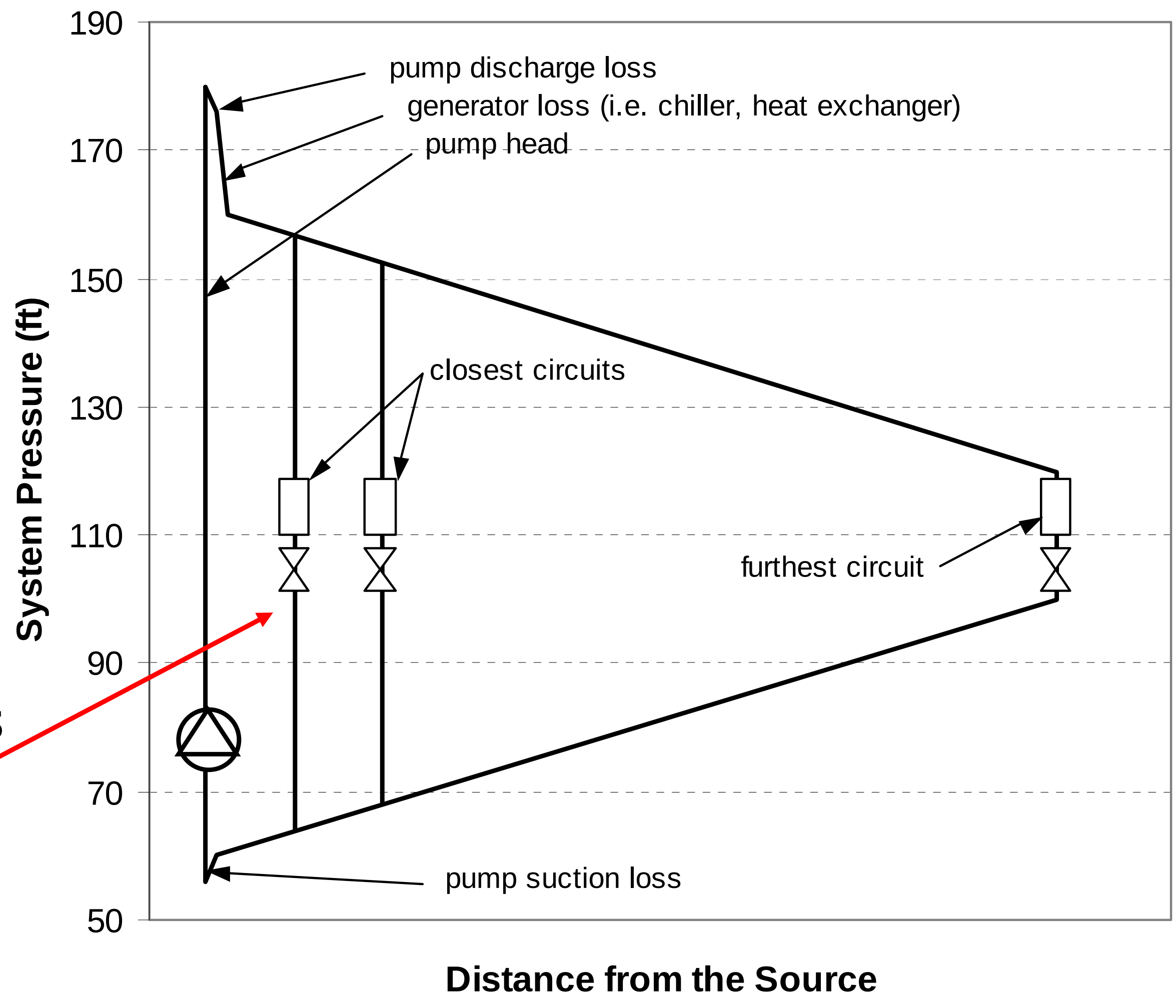
Rule of thumb control valve sizing:

- Line size or one size smaller.
- 5 psi drop (anywhere in system).
- By maximum pump head for the loop.
- Same pressure drop as coil served.
- For authority (with limited DP data).

The problem commonly starts with uncertainty in the hydraulic profile of the system

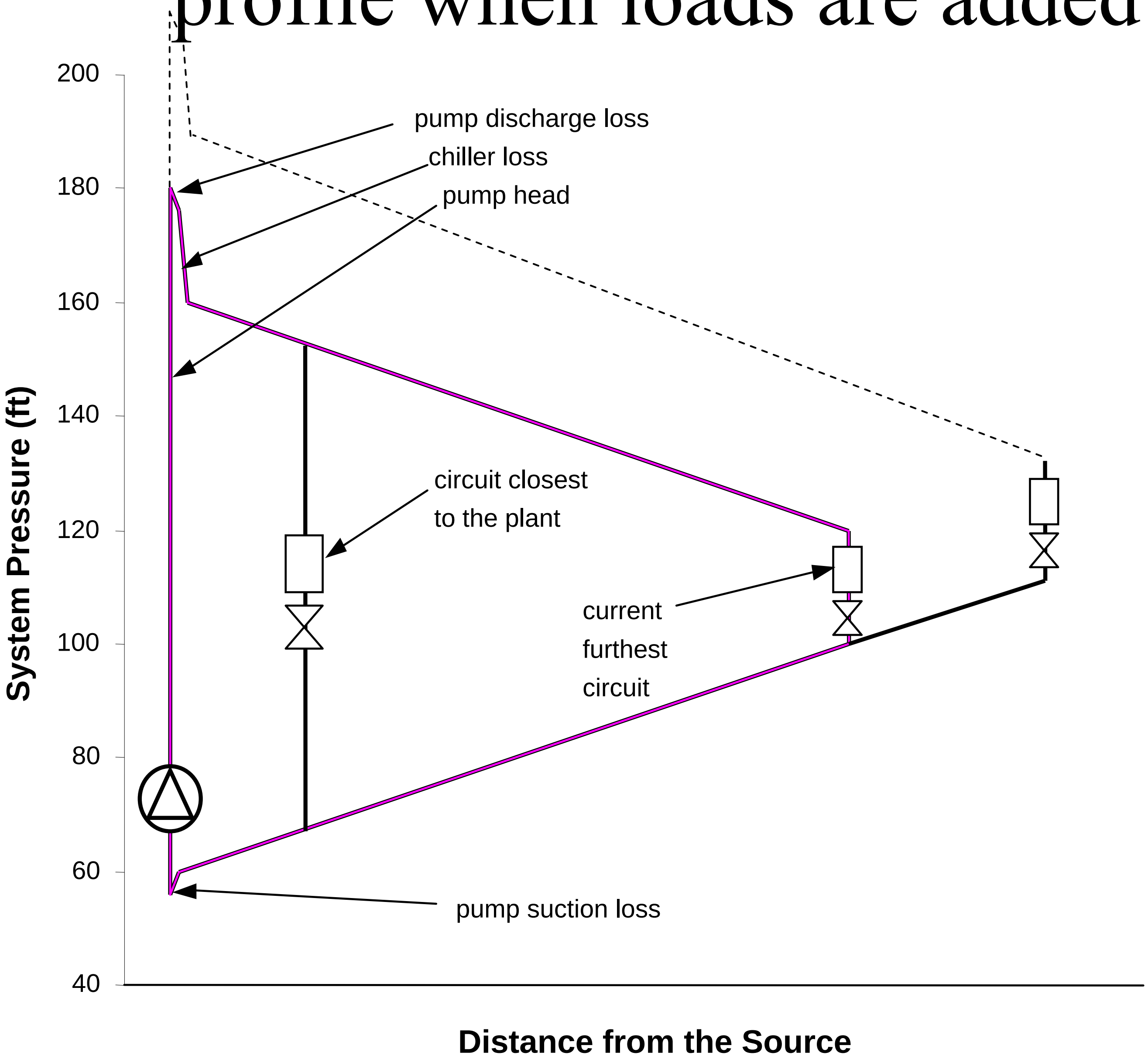
What happens when typical control valves are sized by minimum pressure drop?

Valve
Rangeability
vs.
System
Turndown



Conventional control valves close to the plant may only use a small portion of their full range.

What happens (tomorrow) to the hydraulic profile when loads are added or changed?

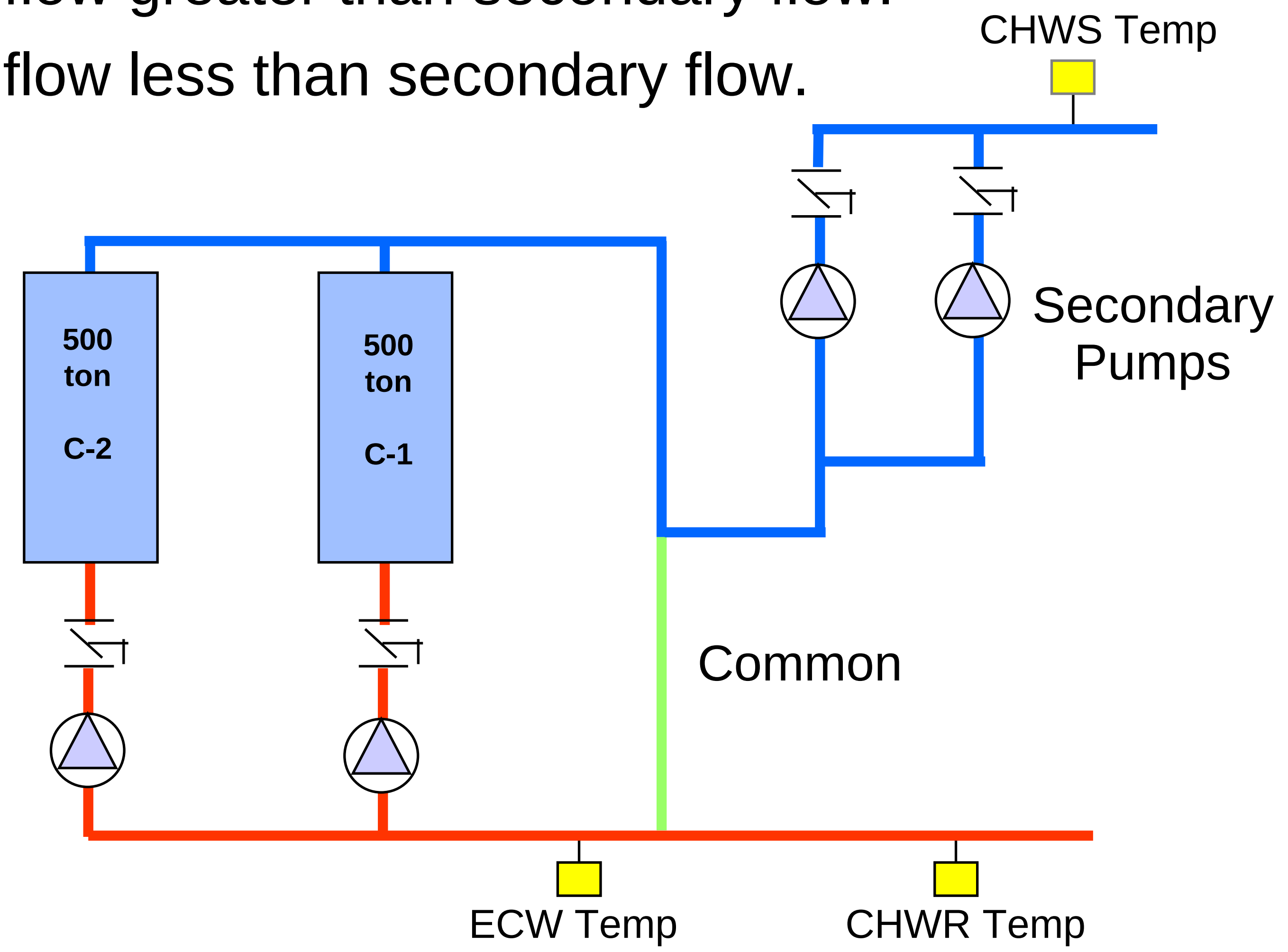


3 Possible Conditions of conventional primary / secondary production plant:

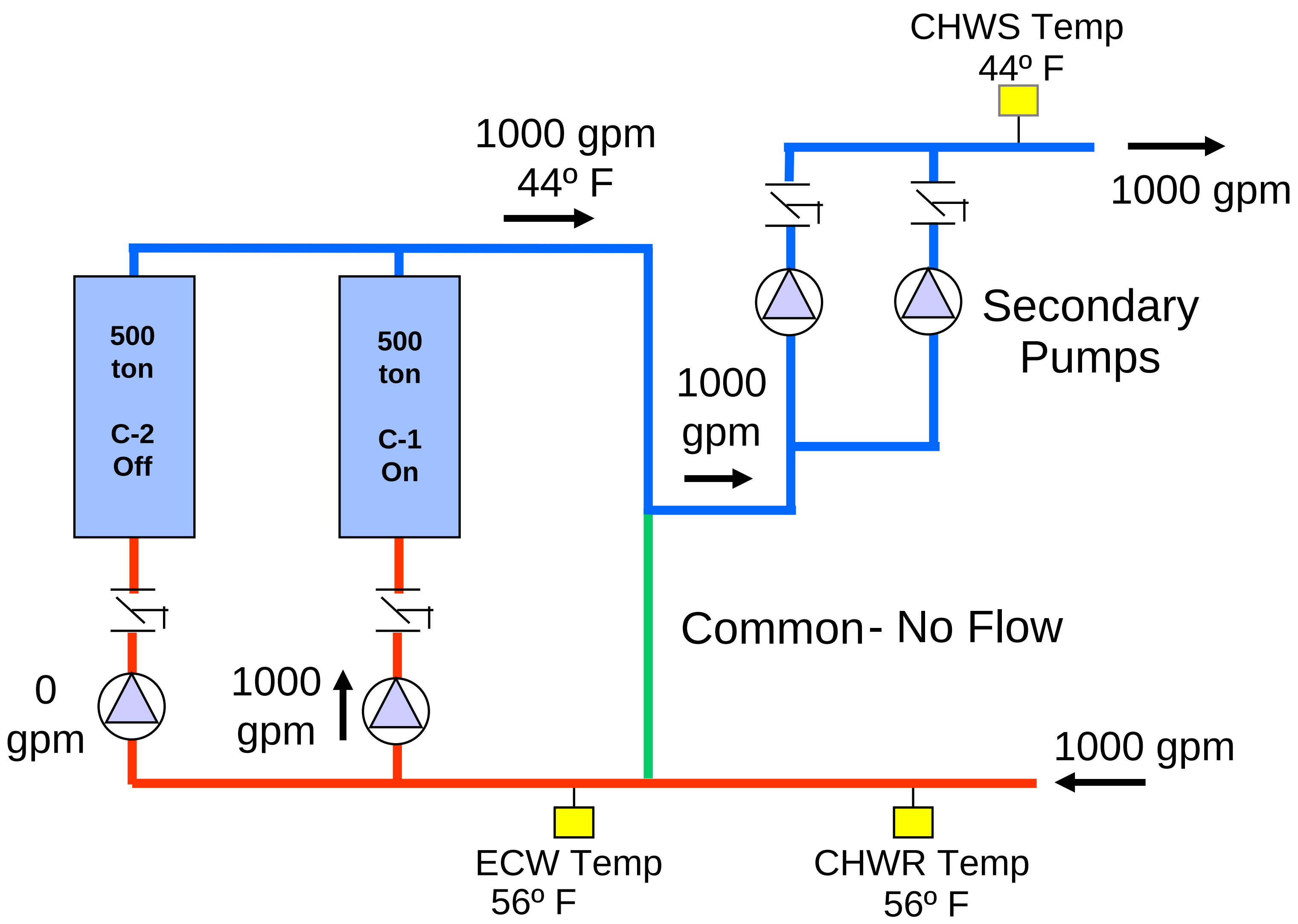
Primary flow equal to secondary flow.

Primary flow greater than secondary flow.

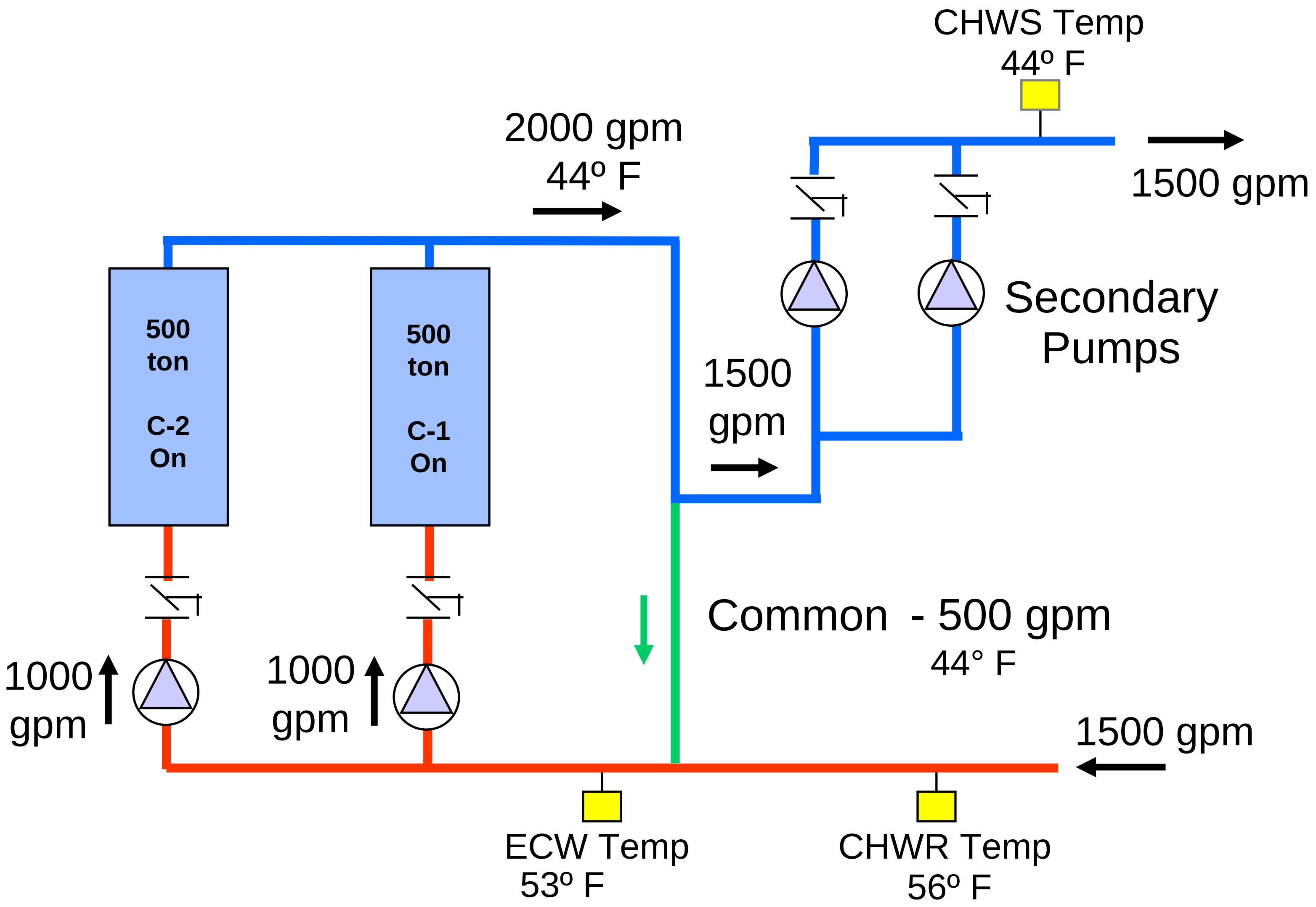
Primary flow less than secondary flow.



Primary flow equal to secondary flow:

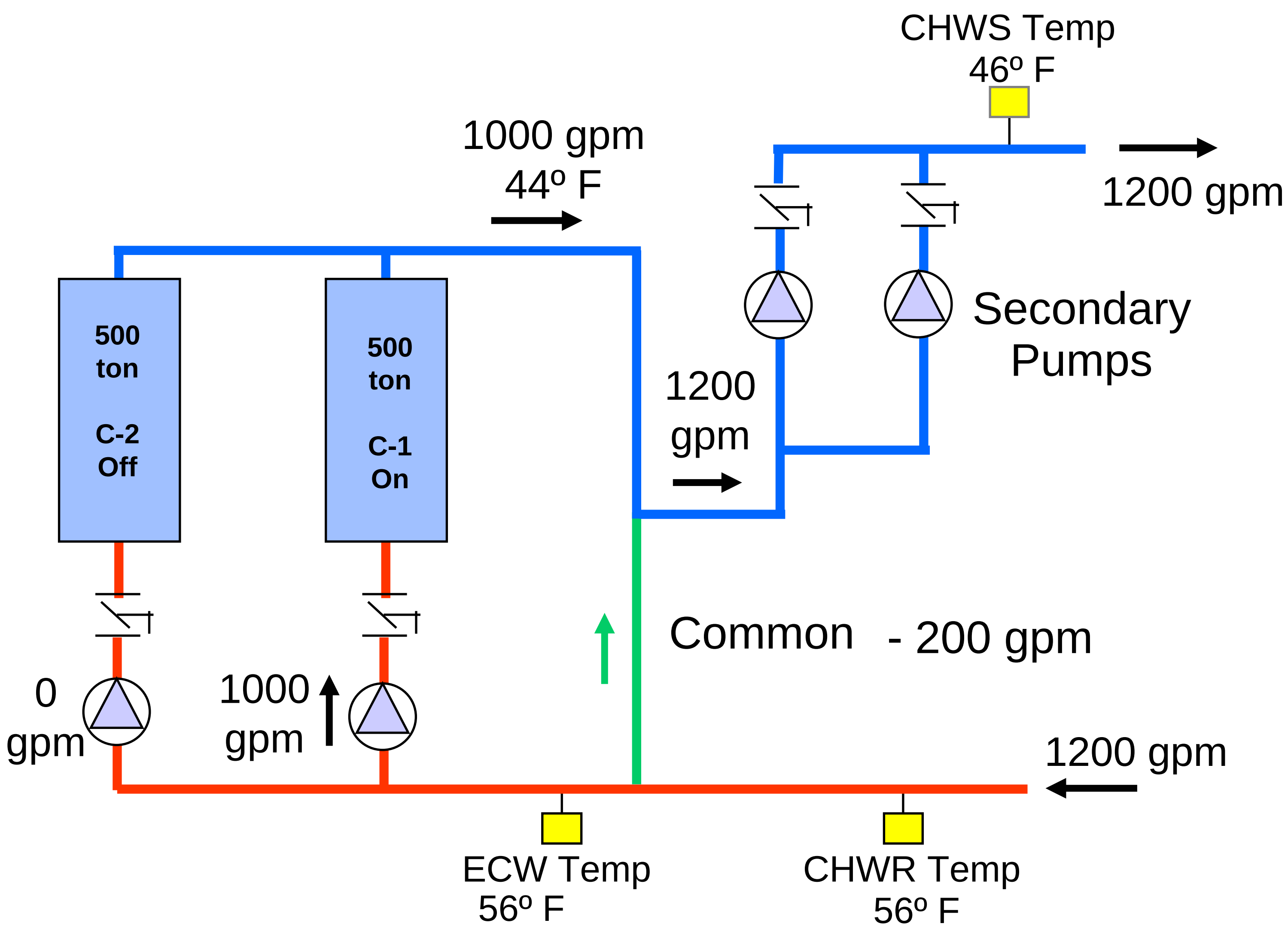


Primary flow greater than secondary flow:



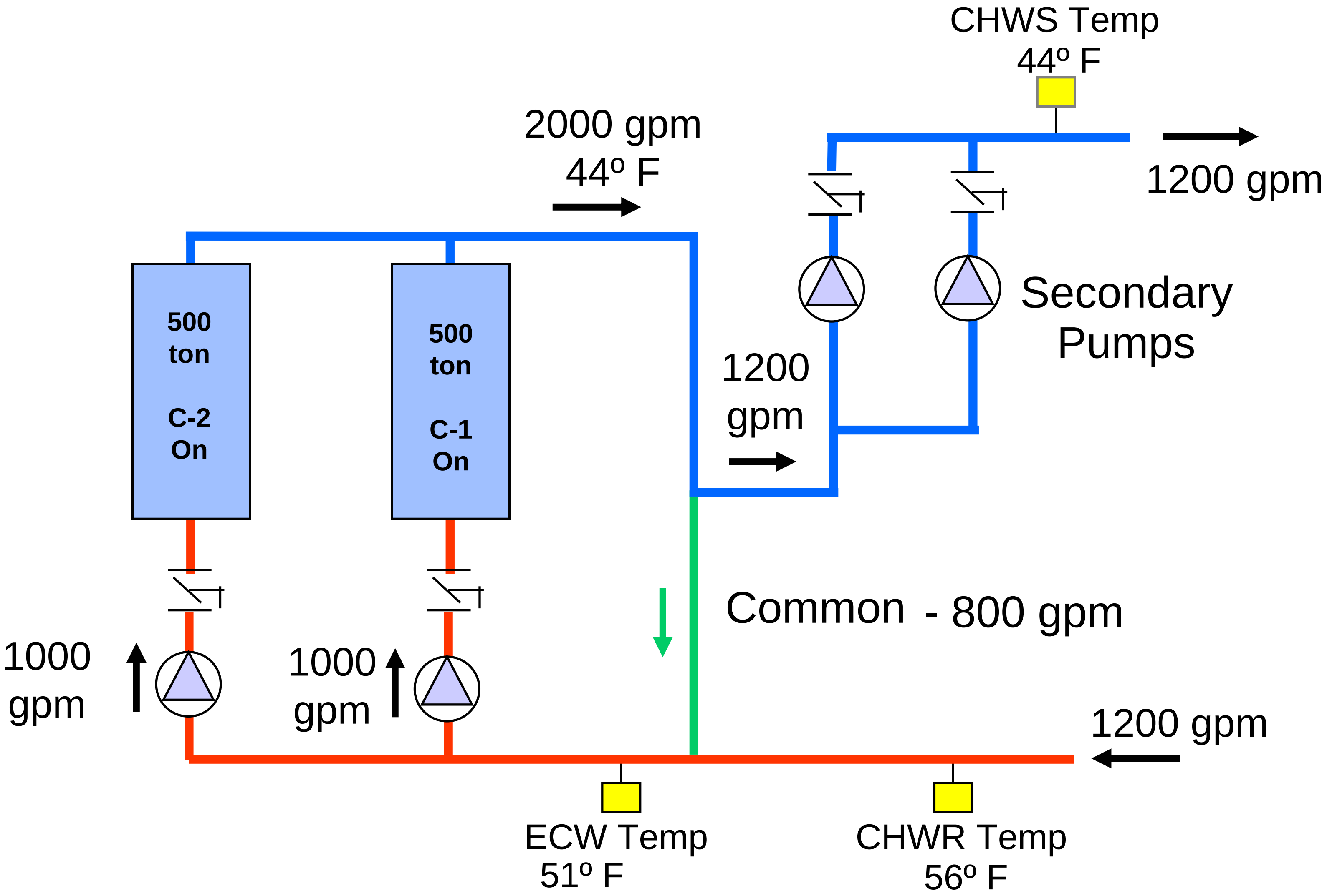
Each chiller is 75% loaded (9º/12º)

Primary flow less than secondary flow:

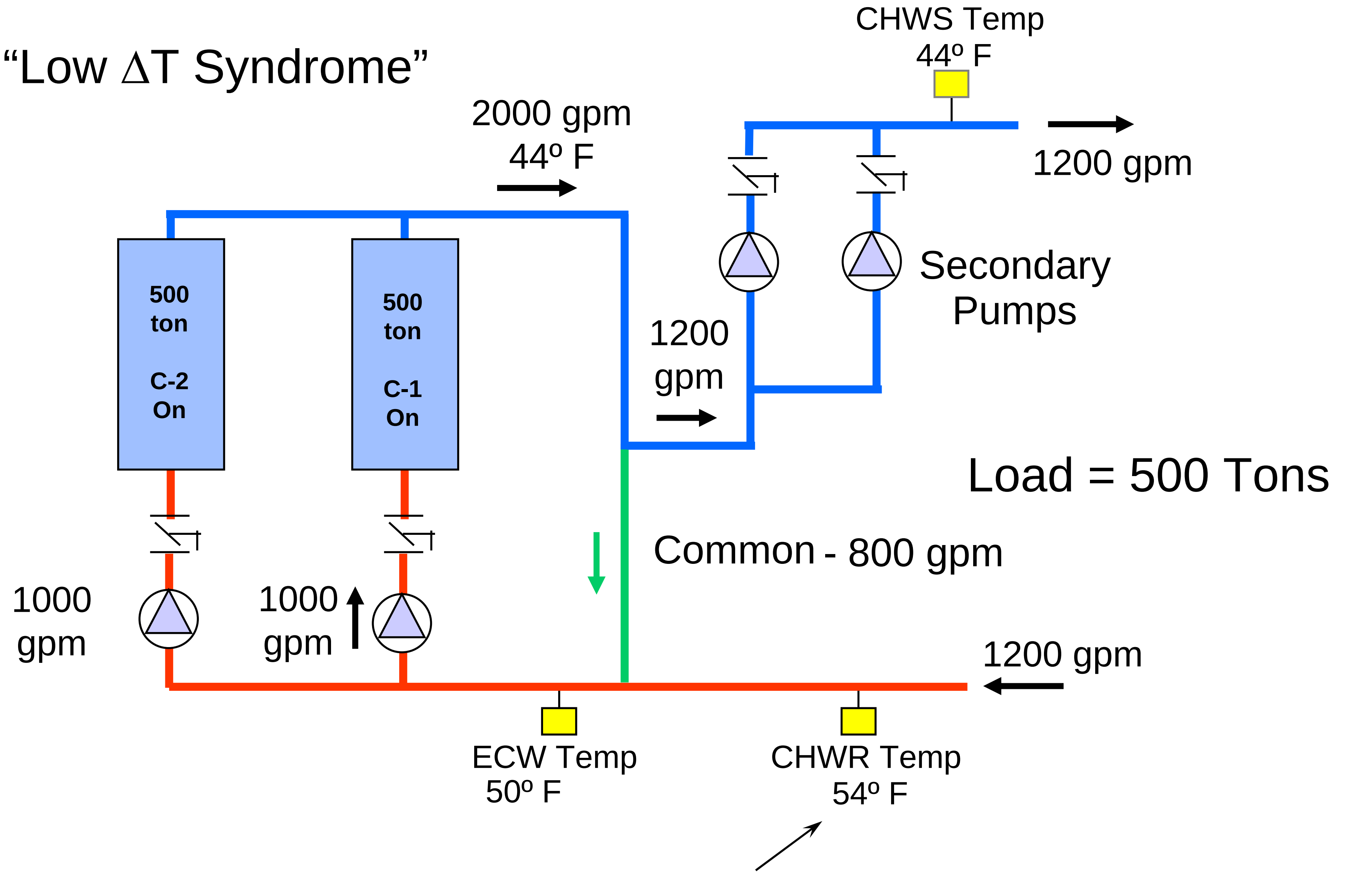


Stage on Chiller #2, to get….

Note: when we turned on primary pump #2, the primary flow increased to 2000 gpm, but secondary flow remained at 1200 gpm.



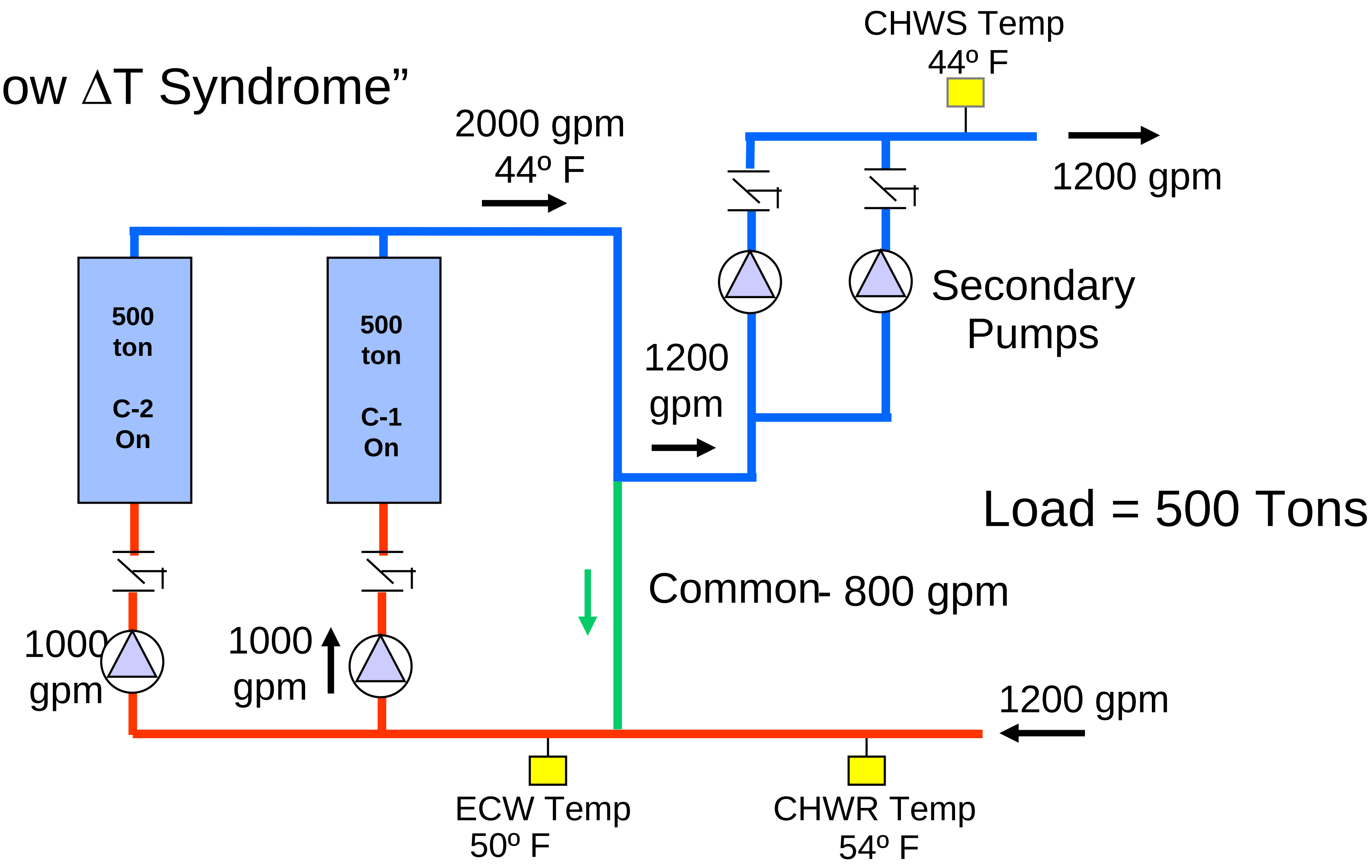
“Low ΔT Syndrome”



With 54º F return water from the system, we cannot meet the 500 ton load with one chiller

Let’s look at wasted energy in this example because of the low Δt…

“Low ΔT Syndrome”



- Our pump bhp on the primary side is over twice than what it would be with a 12º Δt
- We are pumping 20% more flow on secondary side. Secondary pump bhp increase of ≈ 60%
- Running 2 chillers instead of 1; 2 towers instead of 1; and 2 condenser pumps instead of 1
- Our chiller plant cannot meet a 1000 load with the low Δt…

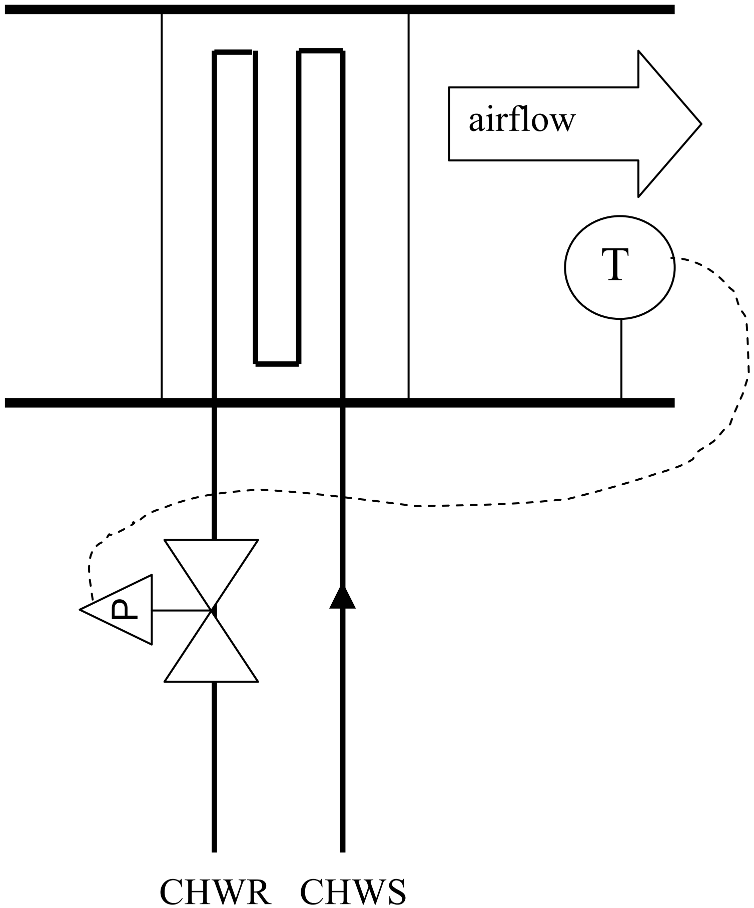
Changes we can make to meet the 1000 ton load in our example

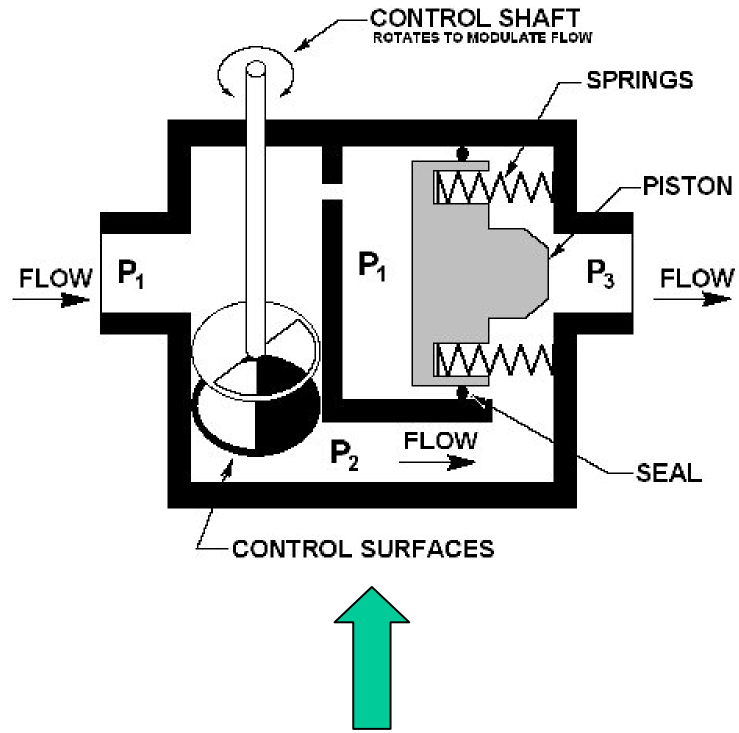
- Fix the low Δt problem out in the system (low Δt is caused by a problem out in the system… it is *not* caused by primary-secondary)
- Buy a 170-ton chiller

PREVENTING LOW ΔT:

High Quality Pressure Independent Modulating Control Valves Are a Solution to Low ΔT

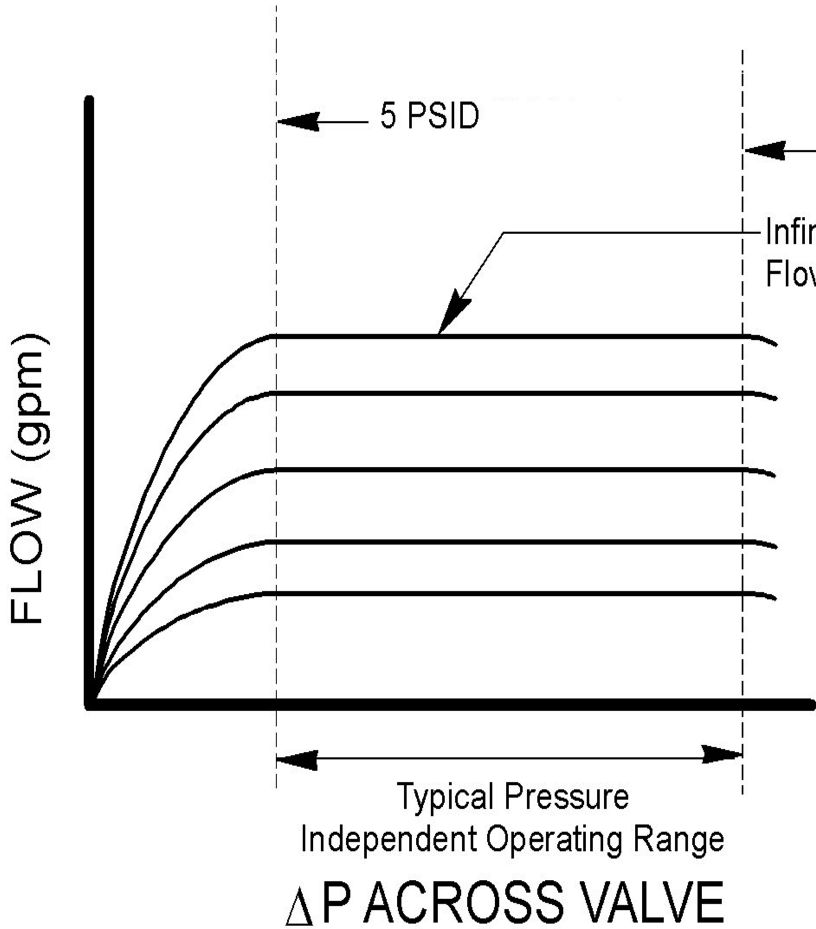
Pressure Independent Modulating Control Valves only react to changes in the load





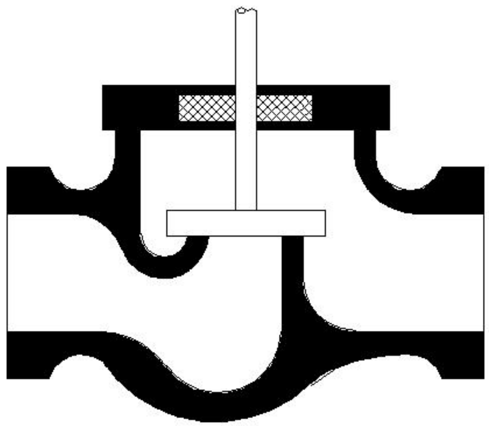
Flow is steadied by maintaining constant differential pressure across the control surface

Flow remains steady over a wide operating pressure range:



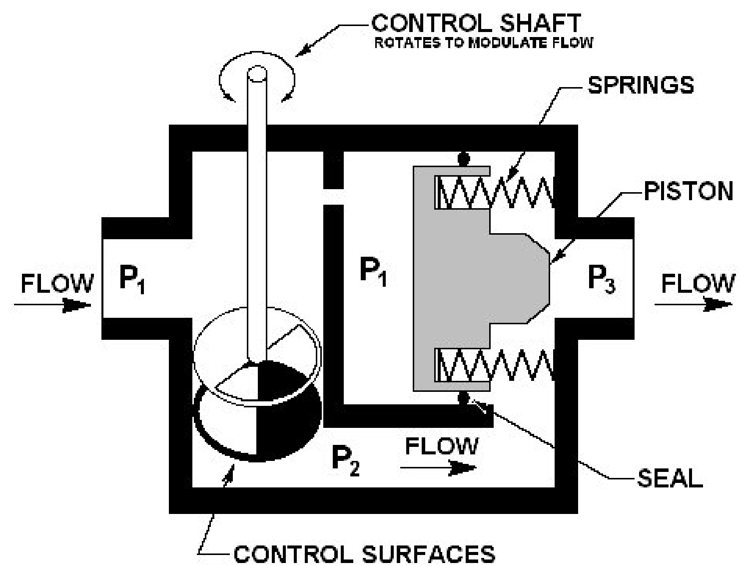
Applied at coils, these valves make the system ROBUST to real time fluctuations in pressure AND uncertainty in the hydraulic profile.

Pressure independent control valves don't care about pressures:



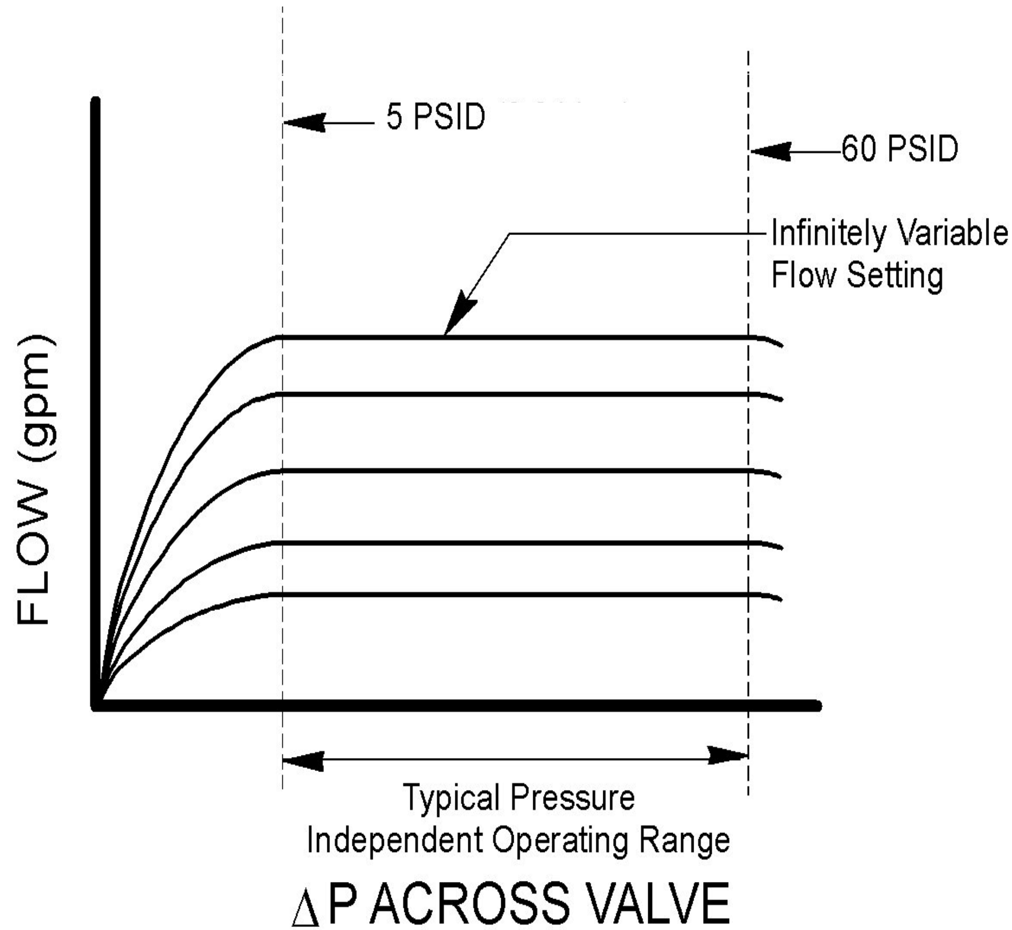
Conventional Control Valve

Flow varies as differential pressure varies

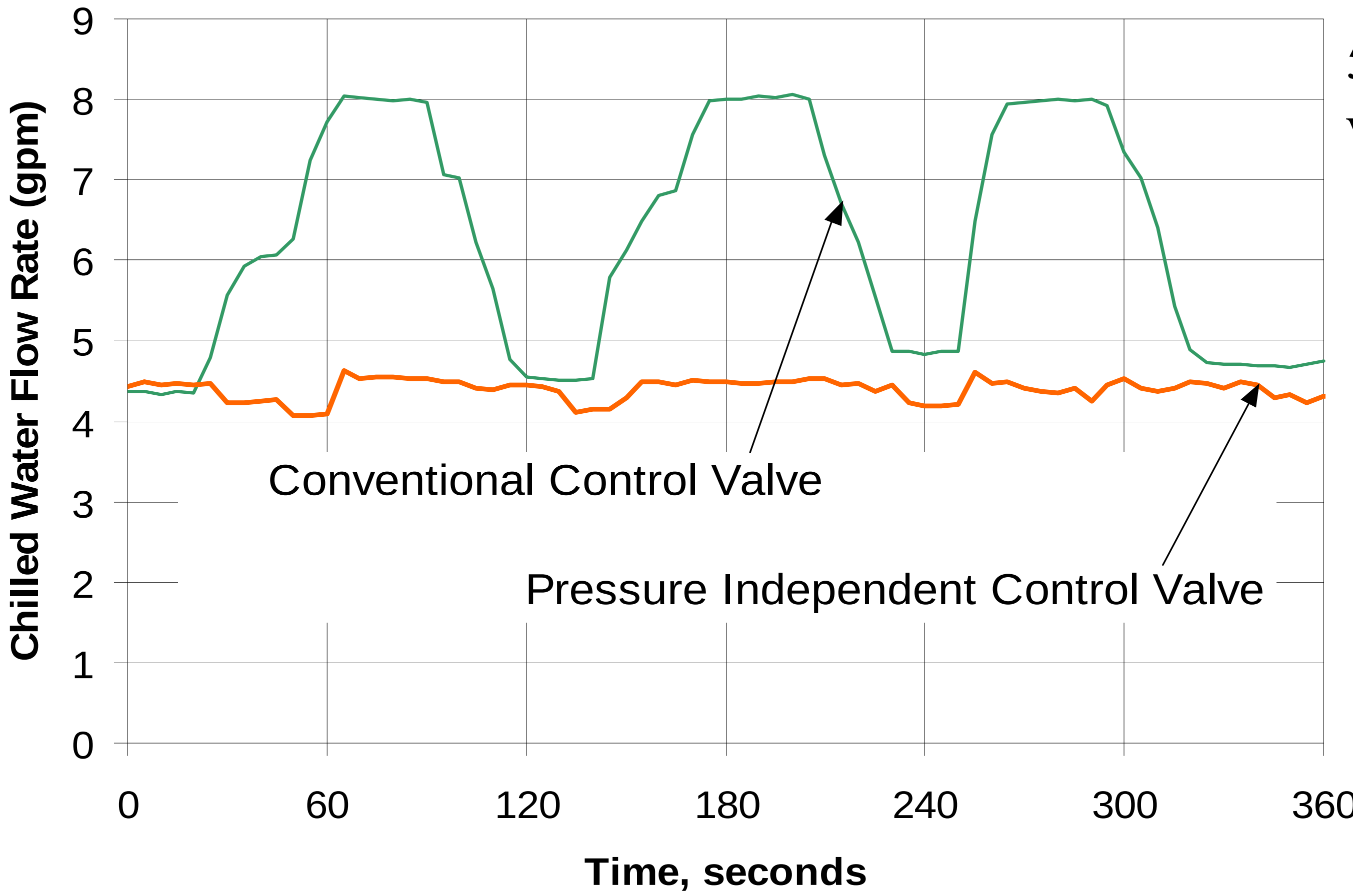


Flow is steadied by maintaining constant differential pressure across the control surface

Flow remains steady in a wide operating pressure range



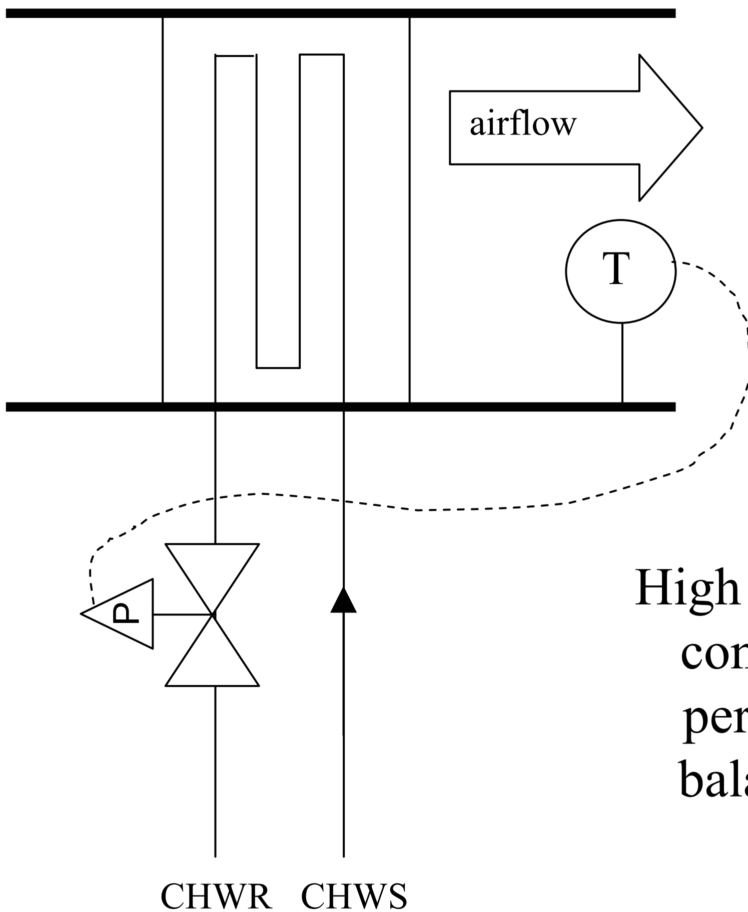
Pressure variations have no effect on the flow rate through cooling coils



5-15 psid pressure variations induced

<u>IT TAKES TIME</u> FOR A CONVENTIONAL CONTROL VALVE TO RETURN TO THE RIGHT POSITION TO SERVE THE COOLING LOAD. CONTROL VALVE "HUNTING" CONTRIBUTES TO LOW DELTA T

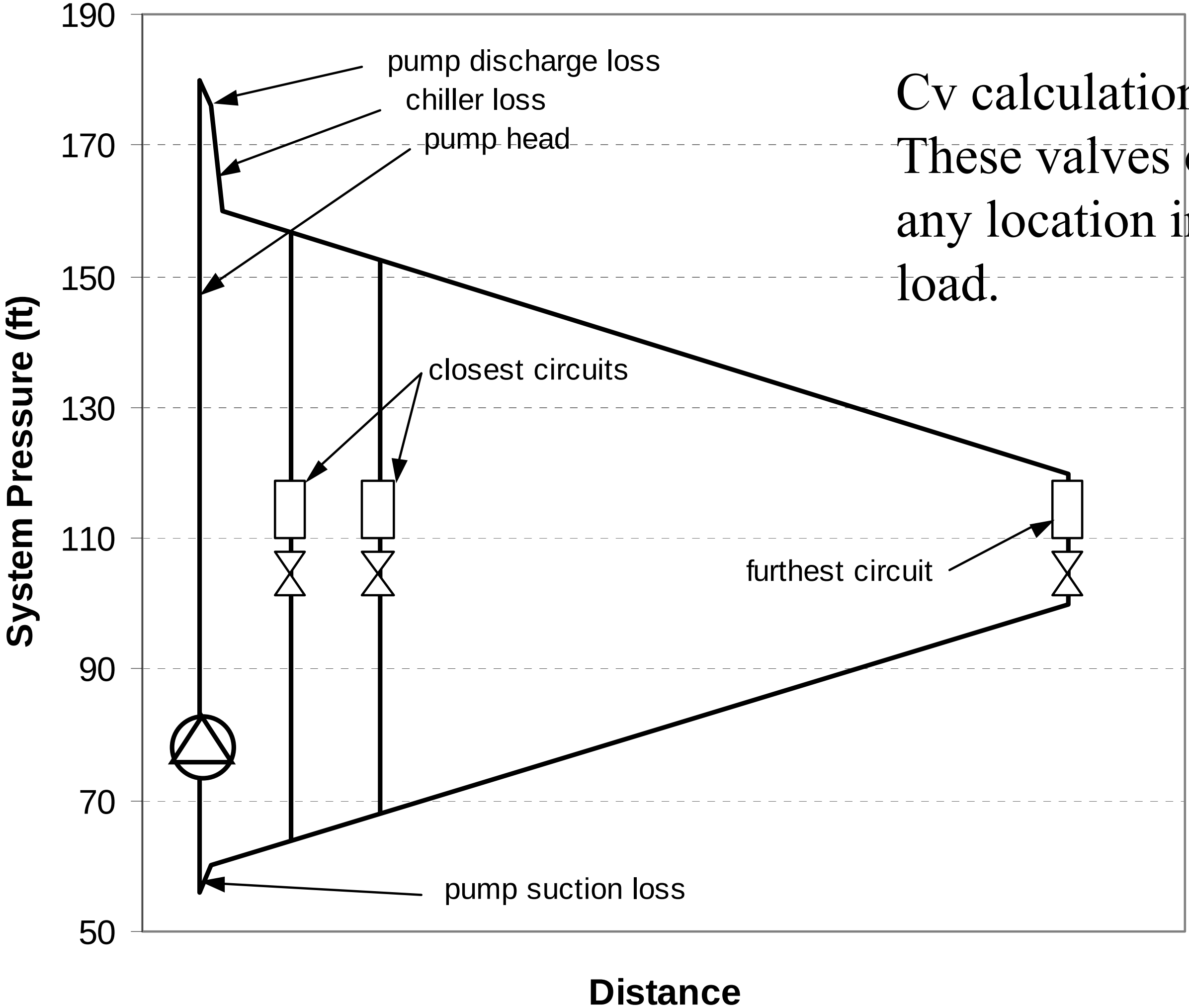
They are typically applied at terminal unit cooling coils:



Leaving air temperature thermostat alone usually sets the demand for chilled water flow.

High quality pressure independent control valve optimize delta T performance and dynamically balances the system at all load conditions.

They are selected by flow rate, not Cv and differential pressure -



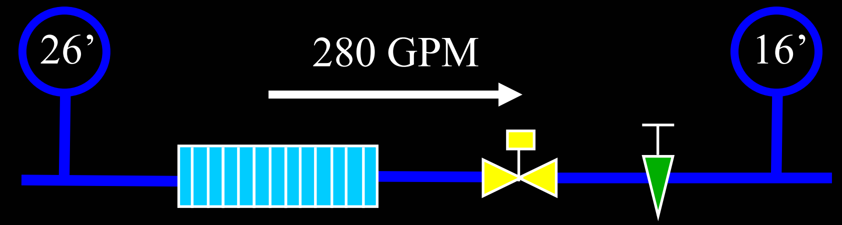
Cv calculations are not required. These valves operates the same at any location in the system at any load.

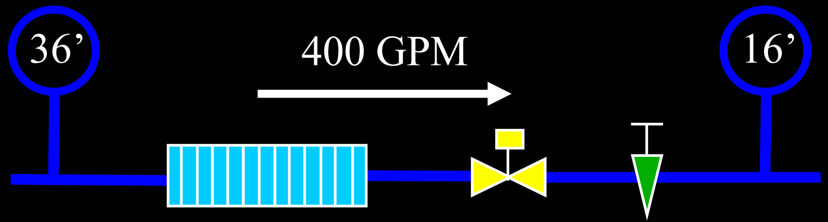
System is robust to future changes in the piping, load or hydraulic profile.

Typical Part Load Day

Design Load = 500 GPM

Conventional Control Valve

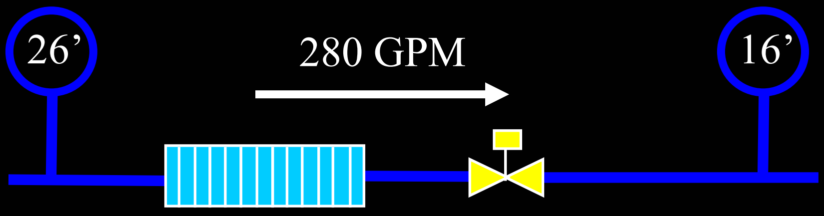


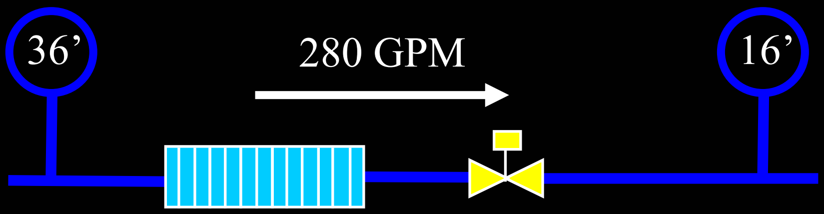


Typical Part Load Day

Design Load = 500 GPM

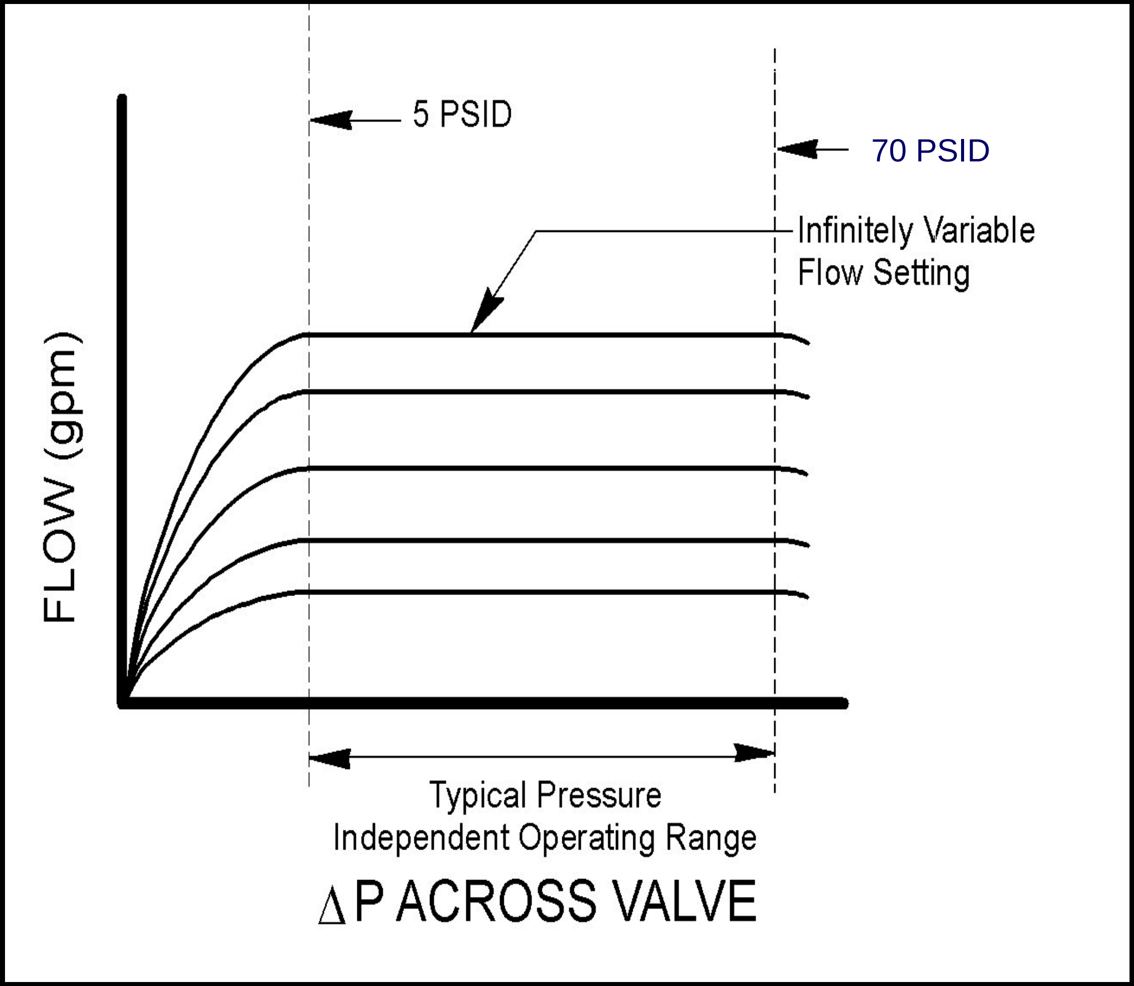
Pressure Independent Control Valve





(note that we no longer need a balance valve)

Flow Rate Doesn't Vary as Differential Pressure Varies



Automatic Flow Limiters –

Will they solve the problem?

Automatic Flow Limiters

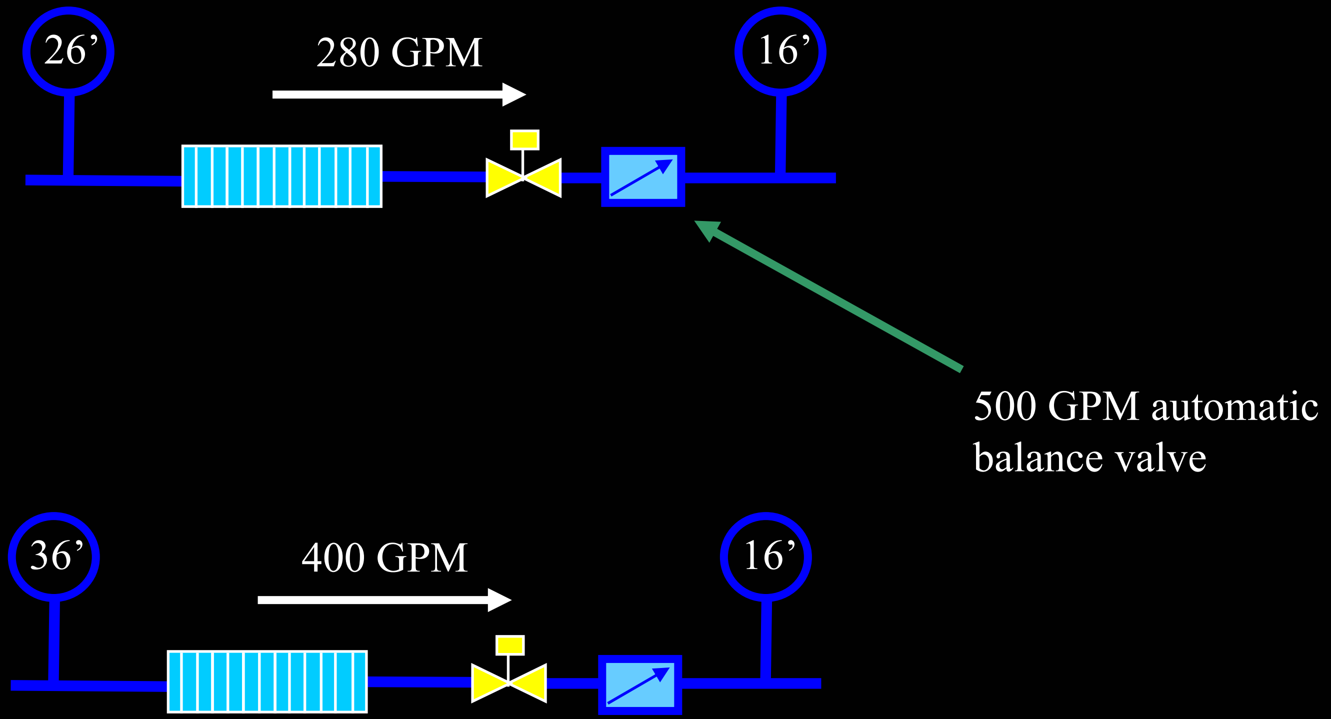
–

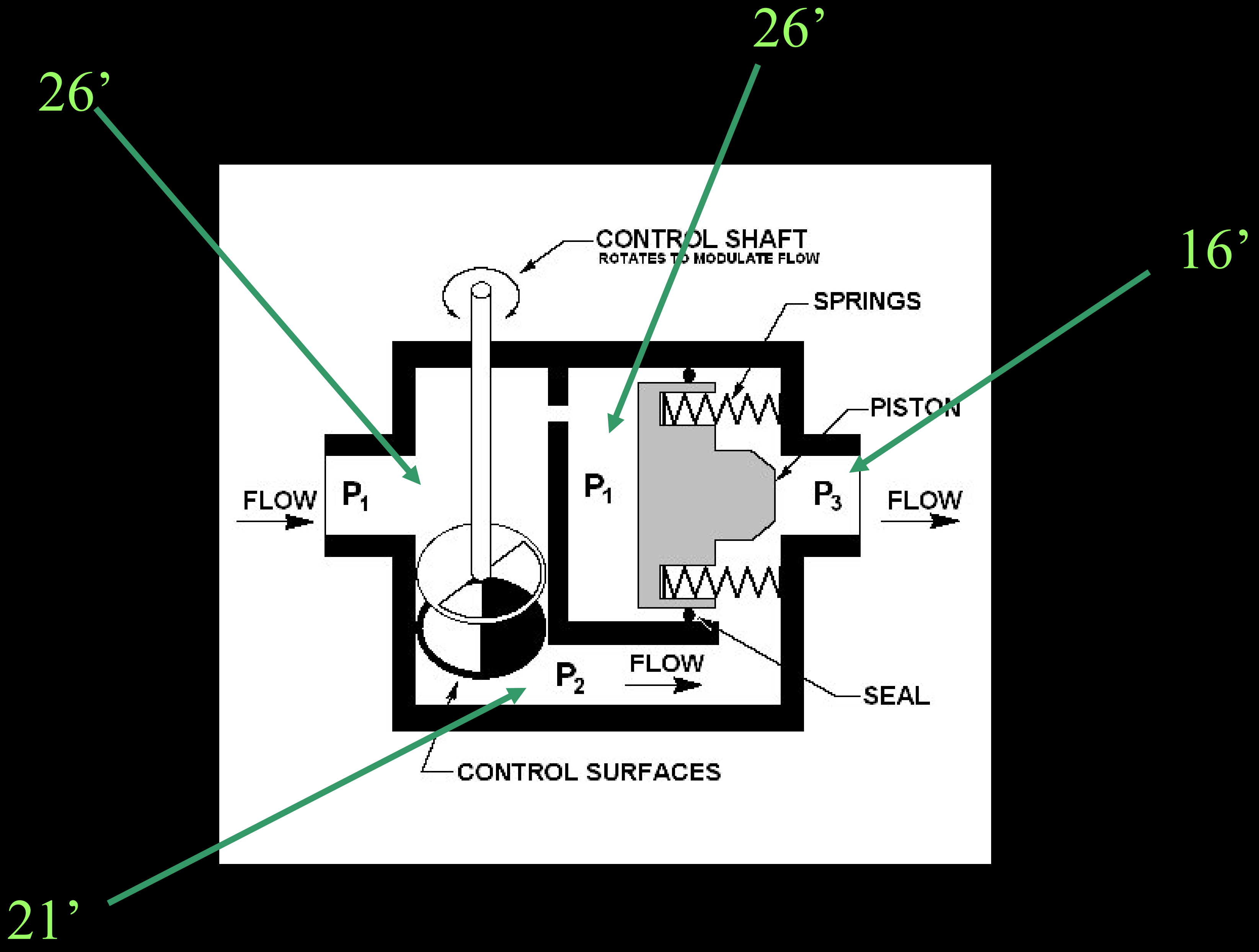
Function as the <u>opposite</u> of Pressure Independent Modulating Control Valves!

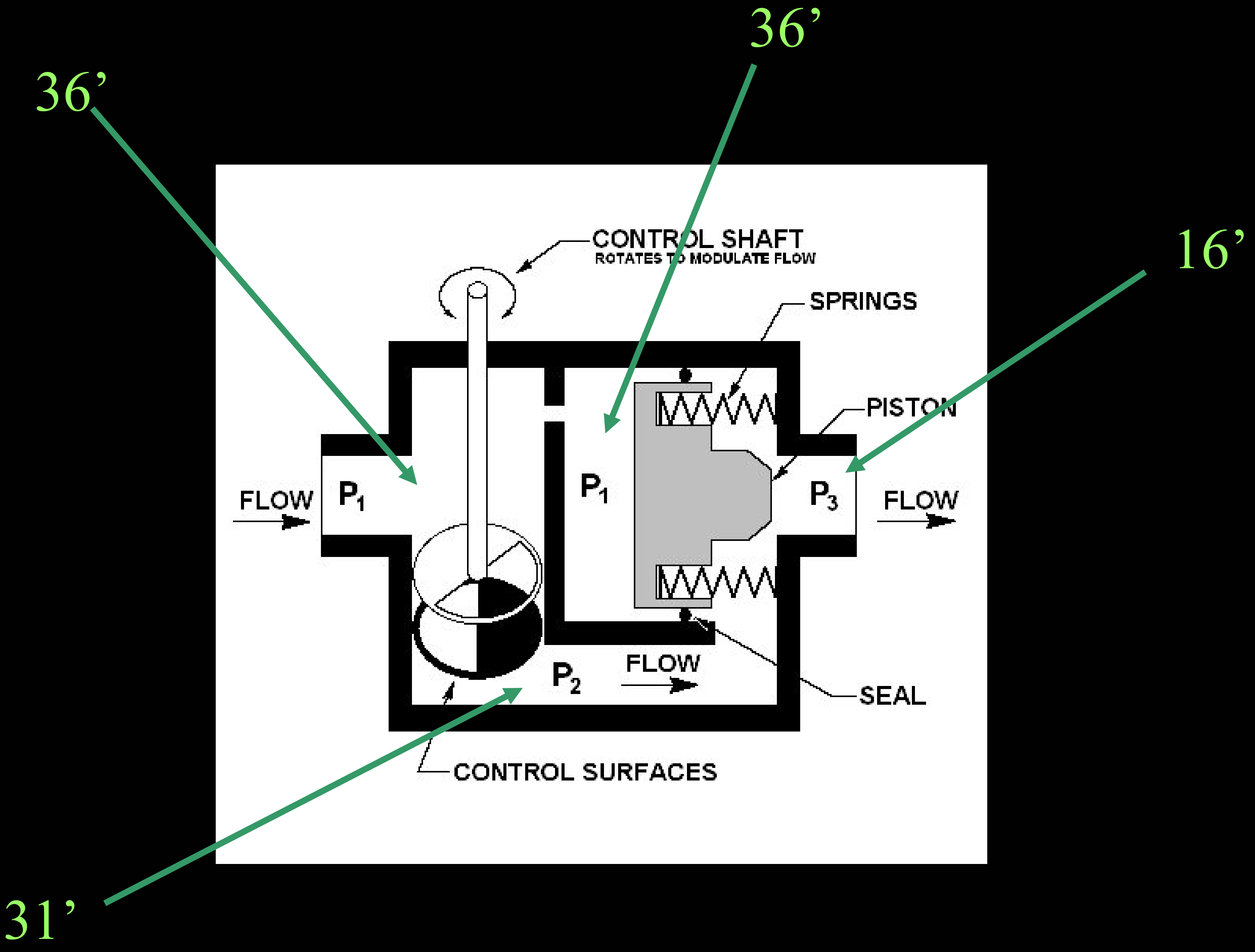
Typical Part Load Day

Conventional Control Valve

Design Load = 500 GPM



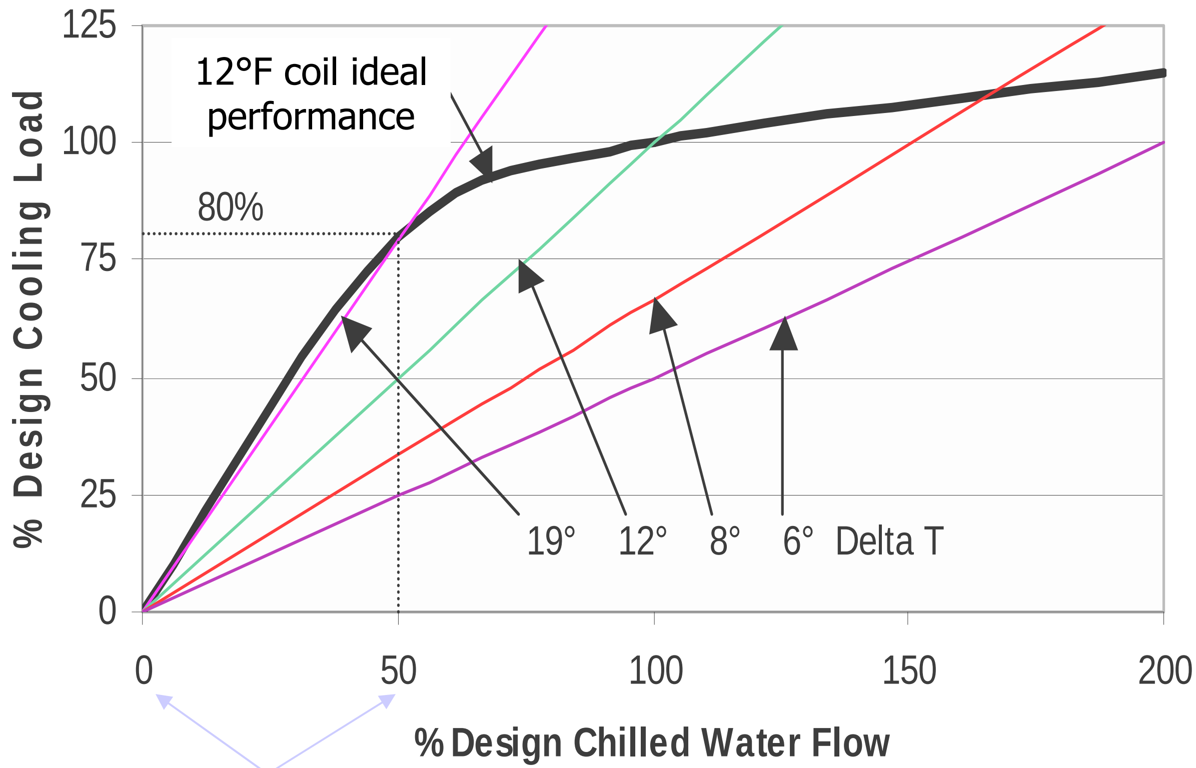

26'
26'
16'
21'
CONTROL SHAFT
ROTATES TO MODULATE FLOW
SPRINGS
PISTON
FLOW
P1
P1
P3
FLOW
P2
FLOW
SEAL
CONTROL SURFACES



36'
36'
16'
31'
CONTROL SHAFT
ROTATES TO MODULATE FLOW
SPRINGS
PISTON
FLOW
P_1
P_1
P_3
FLOW
P_2
FLOW
SEAL
CONTROL SURFACES

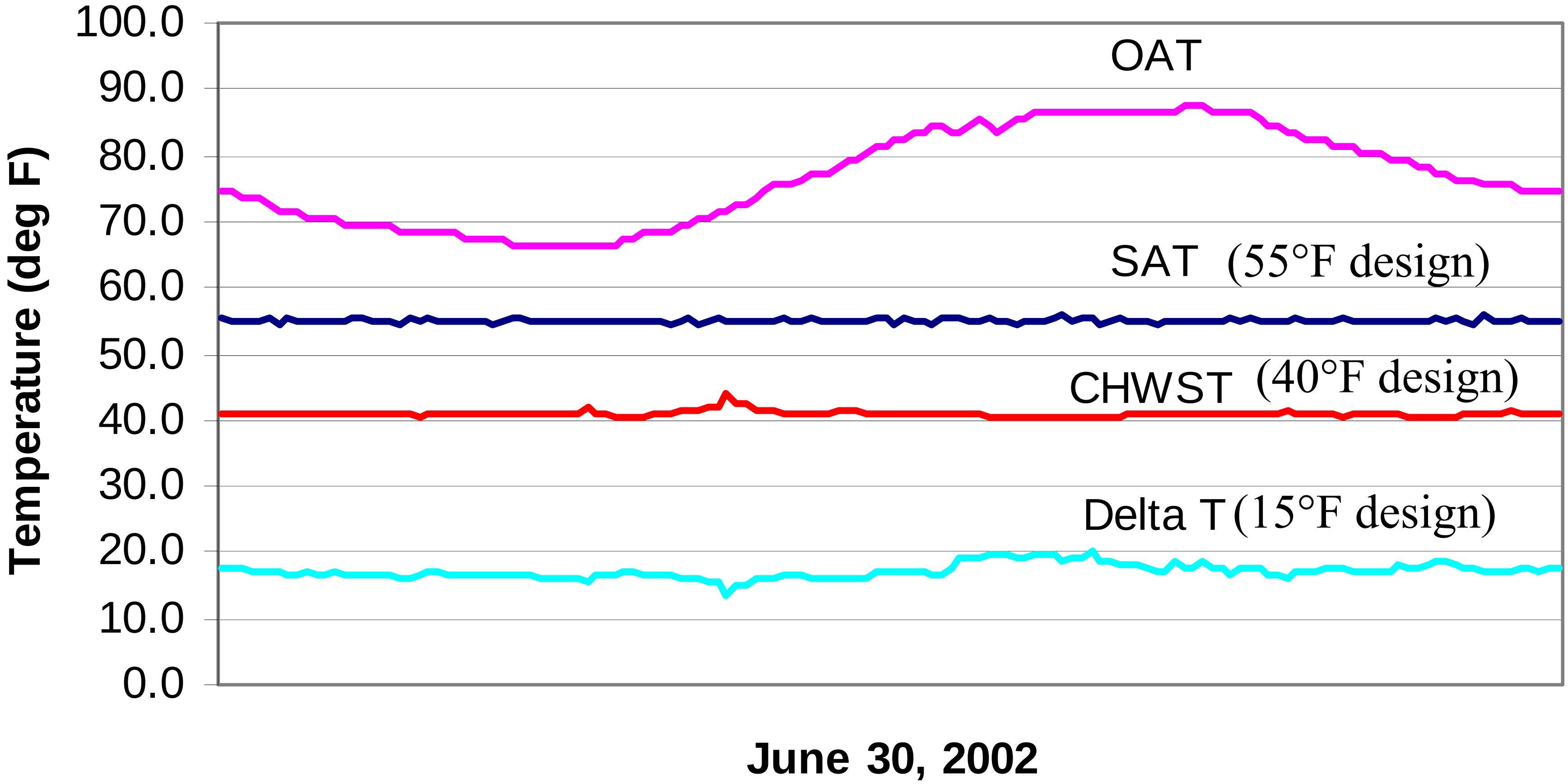
- this enables coil and system ΔT to be optimized at all loads

The BAR is design delta T – the coil delta T should <u>exceed</u> design at <u>all</u> load conditions



Control valves MUST be properly sized and able to control in this range the majority of the time.

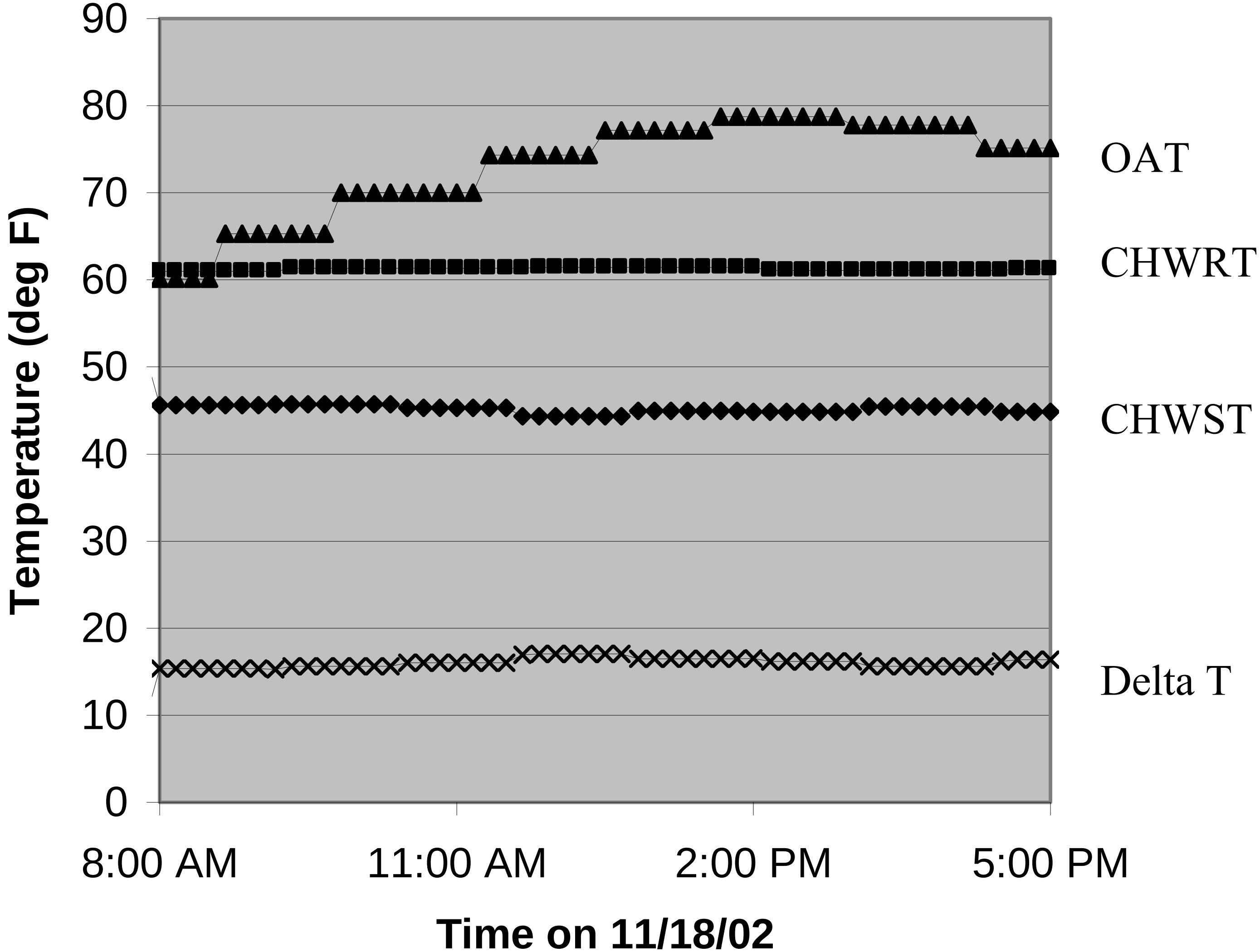
Trend of excellent performance:



Summary – Water Side

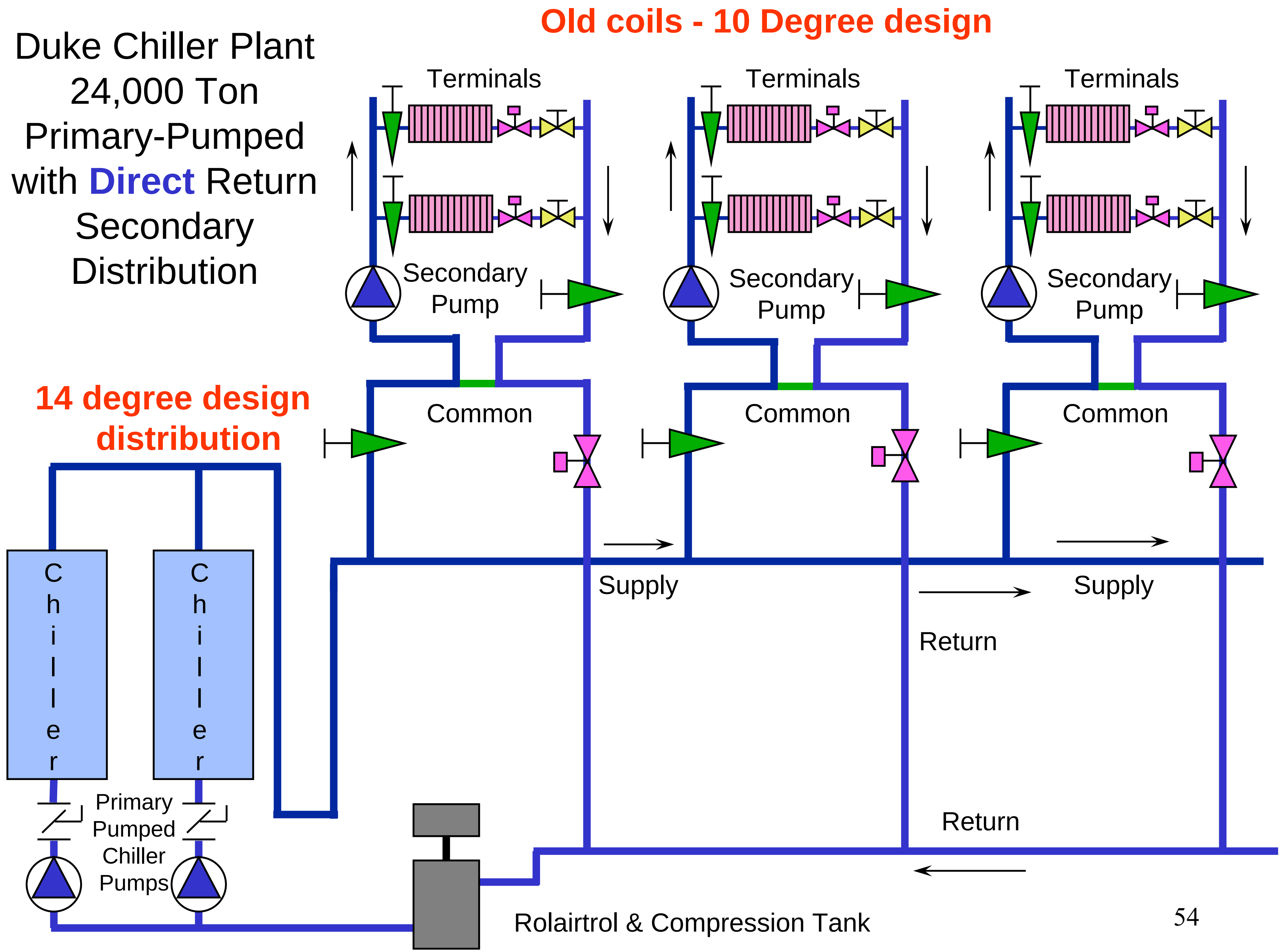
- Measure ΔT across coils and all loops.
- Compare ΔT performance to design.
- If it does not exceed coil design at part load - seek a solution.

How a good system operates:



USC Law Building has 10 and 12°F coils designed for 44° CHWST

Duke Chiller Plant
24,000 Ton
Primary-Pumped
with **Direct** Return
Secondary
Distribution



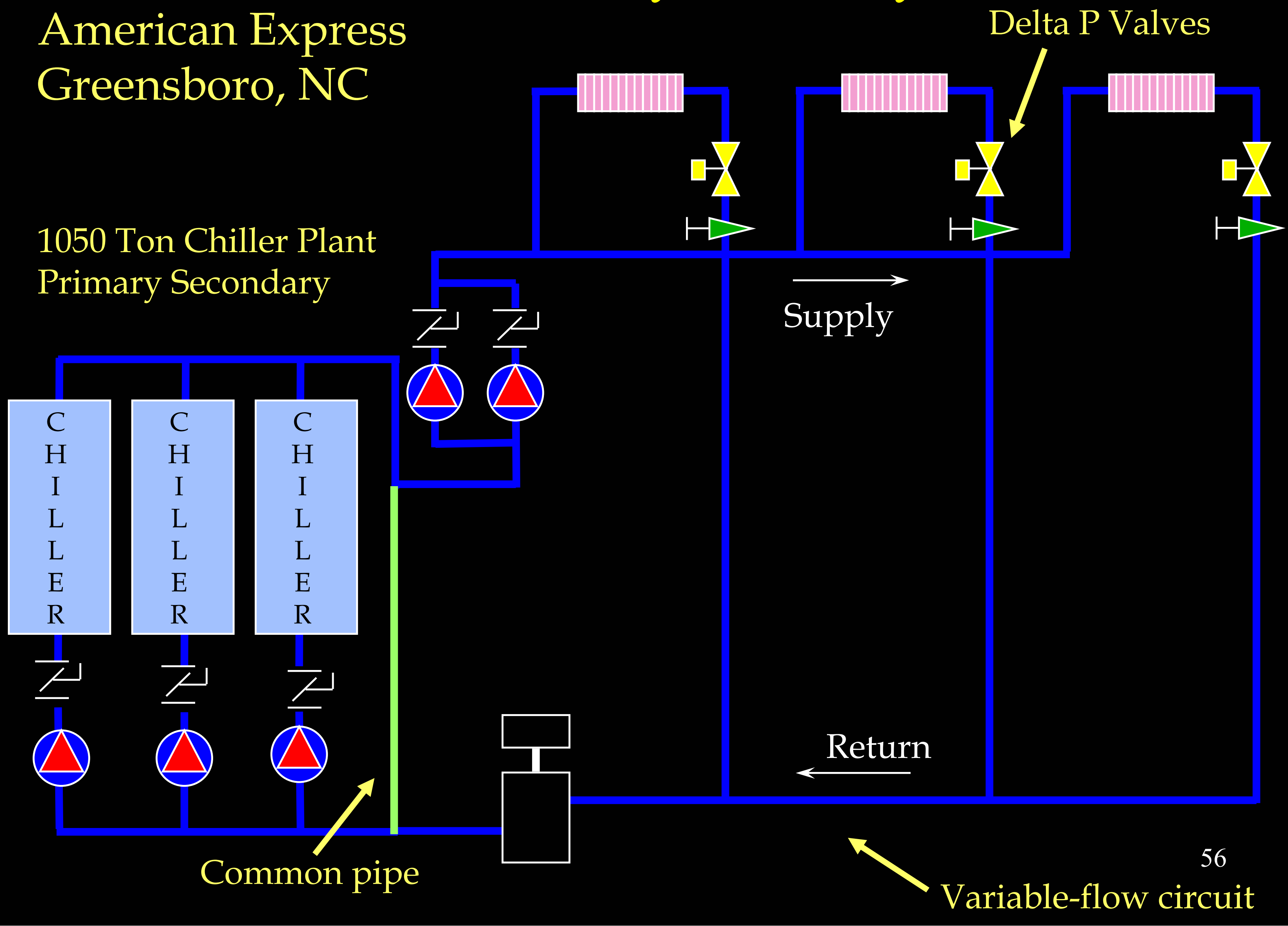
Real World Results at Duke University

Duke has old two way valves and coils that *were* operating at 5 to 6 ° Δ T.

Pressure Independent Control Valves valves on same 10 ° coils and loads *are providing 15 to 20 ° Δ T .*

If you want to visit call or e-mail the JMP CO

Primary-Secondary

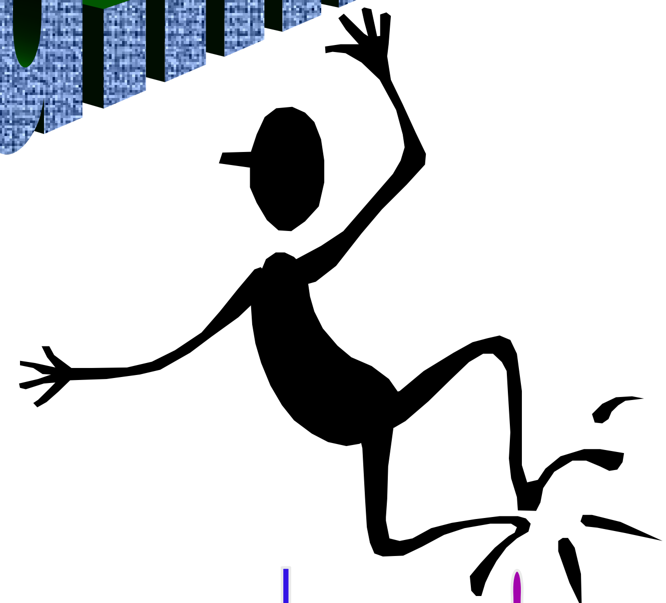


Real World Results at American Express

American Express had old two way valves and coils that were operating at 5 to 6 ° Δ T.

Only 50% or (½ half) valves changed to Pressure Independent Control Valves - on same coils and loads ***are providing 9 to 10 ° Δ T .***

The End.....



Thank you for coming!

Web Site: http://www.jmpco.com